[Phelps, S. L.]

REVIEW

OF

THE PROPOSED

TEHUANTEPEC SHIP RAILWAY.

JUNE 1, 1881.

GIBSON BROTHERS, PRINTERS.

of this guarantee the company agrees: *First:* to transport, for ninety-nine years, the ships, troops, property, and mails of the United States free. *Second:* to carry no other war-vessels or contraband of war of any nation at war with the United States. *Third:* that *all net receipts in excess of a sum sufficient to pay six per cent. dividends shall be paid to the United States to refund any advances* they may have made on account of the guarantee. *Fourth:* to give the United States the right to reduce or increase the tolls at her pleasure, provided the reduction shall not prevent the earning of *eight per centum dividends.* *Fifth:* to give her the right to discriminate in favor of American and Mexican commerce when fixing the tolls."

From what has gone before, it is evident that the trials Captain Eads proposes to entitle him to receive guarantees of $10,-000,000 after each successful experiment would be of no value whatever.

The Government would have secured what?

A road apparently capable of transporting small vessels and not such as are already trading between our Pacific State China, Japan, Australia, and New Zealand—all of which vess would find their home port at New York were there a safe mus ship transit.

There is a contradiction in this paragraph as to the gua to be received after the first successful trial; but it is to be stated correctly in the last reference, as it acc the amount to be secured in further trials,

The first one, it is proposed, shall be with a vesse weighing 2,000 tons. This would be represented steamer 230 feet long, 30 feet beam, and 16 feet

The ship-car would be 130 feet long, 30 feet 12 rails, would take 516 wheels. Total load 4, tons per wheel.

The first trial would therefore fail, because pressure over the maximum of 5 tons per wh these dimensions sometimes draws 18 feet The loaded vessel would then weigh over pressure upon each wheel would become

The weights of vessel and load at ea be, respectively, as follows:

First trial, vessel and cargo to weig
Second " " " "
Third " " " "
Fourth " " " "
Fifth " " " "

SYNOPSIS OF CONTENTS.

General discussion of various points not mentioned by Captain Eads.

APPENDIX.

Captain James B. Eads has presented a project for a ship-railway across the Isthmus of Tehuantepec to transport from ocean to ocean freighted merchantmen and ships of war, and has asked the assistance of the United States in the sum of $50,000,000.

In an article published in the March number of the North American Review entitled, "The Isthmian Ship-Railway," he claims the highest order of engineering skill, and presents statements and arguments in support of his project.

The entire article is reproduced below with comments on the successive paragraphs, which are numbered for reference. The attention of readers is invited thereto that each may determine for himself the degree of care and study Captain Eads had given to his subject and the weight due to his statements and assertions.

The discussion is one of importance, and should be entered upon with a care commensurate with its gravity. Bare assertions, hasty estimates, and careless examinations are out of place when considering a subject involving a vast outlay of money and many national interests.

S. L. PHELPS.

[1.]

THE ISTHMIAN SHIP-RAILWAY.

"The question of a transit for ocean vessels through the American Isthmus has occupied the attention of the civilized world for the last three hundred and fifty years. The great benefits which such a work would confer upon commerce were fully recognized even in the days of Cortez; and each year since has increased its necessity. The question naturally arises, Why has this great work been so long delayed? The answer lies in the fact that the majority of mankind cling to *old methods rather than adopt new ones, even when the old ones are far more expensive and less efficient. It matters not that the untried ones rest upon the most evident deductions which can be drawn from scientific research or undisputed facts.* Until they are demonstrated by actual test, those who propose them are looked upon as visionary enthusiasts. The opposition to the introduction of the steam-engine, steam-loom, steamboat, locomotive, and electric telegraph furnishes abundant evidence of the hesitancy and reluctance with which even the most intelligent communities adopt new methods."

"For over forty years futile efforts were made to deepen the mouth of the Mississippi by the *antiquated means of dredge-boats.* When these were found inadequate, the only solution deemed possible was the *still more ancient and expensive one of a canal, to be cut through the eastern bank of the river to the Gulf.*"

However great the desire to forbear criticism upon any portion of Captain Eads' article, not strictly relating to the ship-railway question, a due regard for the many serious interests involved compel notice of even those fanciful indulgencies into which he allowed himself to be betrayed, and certainly nothing could be more purely imaginative than the first of the above paragraphs, while the apparent contradiction between it and the following one is curious.

A ship-canal has hitherto been the means contemplated for the transportation of ships across the American Isthmus, and consequently a *canal* has been the "new method," so long delayed in execution; the one which, "resting upon the most "evident deductions which can be drawn from scientific re-"search and undisputed facts," mankind has been "so slow to adopt;" the method that has met with an opposition similar to

NOTE 1.—The paragraphs as commented upon are numbered in order, and reference to them throughout this discussion will be made by placing the number in brackets, thus [12.]

NOTE 2.—Italics used in quotations of the original article are intended to call attention to the particular items commented upon.

that encountered by the "steam-engine, telegraph, steam-loom," &c. A ship-railway has not been discussed for the many years to which he refers and has, therefore, *not been subject to delay in execution.*

He doubtless intended stating that his railway project now encounters opposition, being an invention of the nature and scope of those he cites; but facts would not sustain this pretension, his proposition being merely to apply a familiar means of transportation to the carriage of ships. Its practicability and usefulness may be questioned, but no one will assert that there is anything new or startling in it as an invention.

Had Captain Eads given more study to this branch of his subject, he would have learned that since the earliest examinations and surveys the *ship canal project* has been discussed purely as a national or commercial necessity, or as a business enterprise, and in reference to its great cost and probable receipts. Until recently it could not be shown the business would pay.

The growth of the world's commerce and the developments of our Pacific Empire have changed the aspect of the enterprise from one not likely to give adequate returns to an exceedingly promising undertaking.

[**2.**]

"A proposition to deepen one of the mouths of the river, by concentrating the force of the stream itself upon the bar, *was ridiculed and pronounced impracticable by professional gentlemen of the highest respectability*, and nothing but the offer to guarantee the absolute success of the plan was sufficient to induce the Government to abandon the idea of a canal. In fact, $8,000,000 with which to commence the canal was voted by one branch of Congress, after this offer was made. But it was not until a second commission of engineers was authorized by the Government to investigate the merits of the jetty system that the proposition to attempt the experiment, even at the sole cost and risk of a few private individuals, was sanctioned by the Government."

Since there was nothing new in the proposition to use jetties at the mouth of the Mississippi, it cannot be correctly said that "professional men" ridiculed it.

So much is intended to be conveyed by inference in this paragraph, and such general misapprehension exists as to the Mississippi jetties, that somewhat extended comments in regard to them are proper.

The act of Congress making appropriation for the present jetties was approved March 3, 1875.

On page 841 of the annual report of the Chief of Engineers for 1874 will be found reference to the report of a mixed board of army engineers and naval officers, *assembled in* 1852. This board recommended, "should the dredging processes for which "an appropriation had been made prove failures, that the "money be applied to *the construction of jetties in the Southwest "Pass.*"

In 1856 *a jetty was actually begun.*

On June 30, 1873, a board was convened to consider the report of Captain Howell, U. S. Engineers, concerning a canal to connect the Mississippi with the Gulf. General Barnard, a member, submitted a minority report found on page 832. The closing paragraph is as follows: "Before resorting to an artifi-"cial work of the difficulty and costly character of a ship canal, "a more attentive consideration of the superior advantages of "the natural mouths and of the fair probability of utilizing "them is needed."

The board was then reconvened to consider this question and made a lengthy report on the jetty system. It referred to the use of jetties at the mouth of the Vistula from the year 1594 to 1862 with varying success. The river finally broke through making for itself an artificial channel, which was then made navigable by dredging.

The report was not favorable to the adoption of the jetty system, but General Barnard again submitted a minority report in its favor, using the following language: "I can only reason on "the probabilities deduced from study of the river and the "lights of experience. * * * I feel satisfied in recom-"mending it (jetty system) as probably furnishing the most "speedy attainment of a deep-water channel and one which will "have some features of permanence, * * * and *no engineer "has yet expressed a doubt* as to the fact that concentration of the "waters of one of the passes by jetties carried out to deep "waters *would excavate the required depth of channel.* * * * "* * * * * * * With few exceptions, every harbor "on our northern lakes constituted by a river, or creek mouth, "has been improved by the construction of parallel jetties. "That those were sometimes to be *prolonged* is no denial of their "efficiency."

He quotes the experience in their use in European rivers and

warmly advocated their adoption in the Southwest Pass and condemned the canal project.

In the annual report of the Chief of Engineers, 1875, page 948, will be found the report of a mixed board composed of civilians and Army Engineers. This report is dated January 13, 1875.

It recommended the improvement of the Southwest Pass by jetties of fascine, brush, and stone, in the same general way as had been done at the mouth of the Maas.

It is thus seen that a board assembled for the purpose of examining the question of the improvement of the Mississippi bar *twenty-three years* before Captain Eads secured an appropriation, had recommended the adoption of the system which he in this paragraph claims as an original idea, so much so as to have been subject to "ridicule."

The construction of a jetty was actually begun in 1856, nineteen years before Captain Eads began operations.

[3.]

"*At the Congress of distinguished engineers from all parts of the world, assembled in Paris in* 1878, at the instance of Count de Lesseps, to investigate the question of interoceanic transit across the American Isthmus, the only plan considered was that of a canal, and the decision was that the problem should be solved by a sea-level one at Panama. Its cost was estimated at twelve hundred million francs, or about two hundred and forty million dollars. Subsequently, more careful estimates reduced this amount to $168,000,000, without including interest during construction."

That few of the members of the Paris Canal Congress were engineers is well known.

Nineteen of the 72 votes cast in favor of the Panama route were given *by engineers*, 8 *of whom* were then, or had been, in the employ of the Suez Canal Company, under the control of Count de Lesseps, and five of the others were not practical engineers. (See reports of Admiral Ammen, U. S. Navy, and of A. G. Menocal, Civil Engineer, U. S. N., to Hon. Wm. M. Evarts, Secretary of State; also publications of Bataille Straatman, Member of the Society of Civil Engineers, Paris, entitled, "Panama and Nicaragua," &c., Paris, 1881.)

[4.]

"In a locality where, for six months in the year, the rain-fall is incessant and enormous, it is not probable that such a work can be completed in less than twenty years. *But if we assume that it can be done in ten, the interest at five per centum during this time would add* $84,000,000 *to this estimate;* making a grand total of $252,000,000."

The interest to be allowed is *upon installments* as paid, at the rate of 5 per cent. per annum. This would make the correct amount upon $168,000,000 for ten years about $46,200,000, and not $84,000,000. Error in statement, $37,800,000.

[5.]

"In the last half century science has made such marvelous advances that, in the department of mechanics, it has placed resources within the reach of the engineer which were totally beyond his grasp before, and it is *now an axiom of the profession that all things are possible, if the necessary money to execute them be provided.* Therefore, a sea-level canal across the Isthmus of Panama is not an impossibility."

Archimides said something very like this many years ago:

[6.]

"The immense rain-fall, and the unhealthfulness of the climate will interpose the greatest obstacles to the work. *So long as the bottom of the canal is kept above the ocean level, the engineer will require only such drainage works and pumping apparatus as are necessary to remove annually water sufficient to cover, to the depth of about thirteen feet, the entire area drained by the canal.* But, knowing the average rain-fall, he will be able to provide means for its removal from his excavations. When, however, the ocean itself is tapped, as it must be in cutting the canal twenty-eight feet below its surface, ordinary methods of drainage become impossible, and the quantity of water which will probably enter through veins and fissures below the ocean level is an unknown quantity, which engineering science cannot determine in advance. Yet even this formidable difficulty may be overcome, if the additional amount of money be provided. The success which has attended the recent subscription to this enterprise seems to prove that there are many people ready to invest their money, on condition that they get five per cent. of it back every year during the time the canal is building, as is promised by the Universal Interoceanic Canal Company. As sixty million dollars are already subscribed to start the canal on these terms, we may fairly conclude that subsequent subscriptions will be sufficient, if judiciously used, not only to pay back five per centum of it annually, and to manage the rain-fall, but also to pump out such part of the ocean as may intrude itself into the works during construction. Annoying delays to commerce may arise from these extraordinary difficulties, but the fact that the shareholders have a five-per-cent dividend-paying stock, tolls or no tolls, will stimulate new subscriptions until the canal is completed, or until this novel method of raising money fails."

Why pump at all when the water can be run off to lower levels?

[7.]

"Of the commerce which will pay the tolls of any transit route for ships across the Isthmus, *three-quarters will probably be American ;* and as the charges will doubtless be in proportion to the cost of the works, it is a matter of prime importance to the commercial interests of the United States to secure the construction of them for the least practicable sum.

"*The total amount of this traffic has been estimated by the chief of the Bureau of Statistics, Mr. Nimmo, to be at present only one million six hundred and twenty-five thousand tons annually.* The Panama projectors estimate it at six million tons."

Mr. Nimmo reported the *total traffic* that might have passed a canal at 2,938,386 tons. (See "The Proposed American Interoceanic Canal in its Commercial Aspects," by Joseph Nimmo, Chief Bureau of Statistics, Treasury Department.)

Of this amount he estimated (for reasons assigned) that but 1,625,000 tons *would have passed through a canal had there been one in* 1879.

The arguments used to justify the deductions made in reaching these low figures would apply to the Tehuantepec ship-railway with greater force than to either the Nicaragua or Panama canals, the business deducted being chiefly that of South America, from which Tehuantepec lies far to the northwest.

An examination of Mr. Nimmo's tables on pages 6, 8 and 9, and the text and appendix relating thereto, will show this more clearly. These tables furnish interesting data for comparison of the relative proportions of the carrying trade between Atlantic and Pacific ports, that might be favored by the Tehuantepec ship-railway and by the Nicaragua ship-canal.

All voyages between ports in either ocean north of the latitude of Tehuantepec, so far as regards *actual distance only*, would be favored more or less by that route; and all voyages between all ports in the Atlantic, and those to the south of Tehuantepec, in the Pacific, would be favored in *all respects via* Nicaragua.

TABLE 1, (page 6, Mr. Nimmo's report.)

Number of vessels and amount of tonnage which might have passed through the proposed canal if it had been constructed.

[N. B.—This table is based upon statistics of the latest year for which the requisite data can be obtained.]

	No. of vessels.	Tons.
1. Average number of vessels and amount of tonnage entered at and cleared from either side of the Isthmus of Panama, annually, in trade with all nations,* (Appendix 2 and 3)............	338	533,000
2. Vessels entered at and cleared from Pacific ports of the United States in trade around Cape Horn with Atlantic ports of the United States during the year ended June 30, 1879,† (Appendix 4)............	75	120,662
3. Vessels entered at and cleared from Atlantic ports of the United States in trade with foreign countries west of Cape Horn, during the year ended June 30, 1879, (Appendix 5)............	273	247,567
4. Vessels entered at and cleared from Pacific ports of the United States in trade with foreign countries east of Cape Horn, during the year ended June 30, 1879, (Appendix 6)............	455	551,929
5. Vessels entered at and cleared from ports of the several countries of Europe in trade around Cape Horn with foreign countries other than the United States, during the latest year for which the data can be stated with respect to each country, (Appendix 7)............	1,644	1,462,897
6. Vessels entered at and cleared from ports of British Columbia in trade with countries of Europe, during the year ended June 30, 1879............	33	22,331
Total............	2,818	2,938,386

*An estimate from the report of the United States Consul at Panama (Appendix 2) and from a statement compiled from British consular returns, (Appendix 3.)
†Compiled from special reports by collectors of customs.

TABLE 2, (page 8,)

Showing the tonnage engaged in guano and nitre carrying, via Cape Horn, a business conducted by sailing-vessels:

	Vessels.	*Tons.*
Westward passages, *via* Cape Horn............	314	314,000
Eastward passages, *via* Cape Horn............	496	496,000
Total............	810	810,000

TABLE 3, (page 9,)

Showing the deductions Mr. Nimmo estimates should be made from the gross amount of trade which might have passed through a canal, as shown per table, page 6, amounting to 2,938,386 tons:

	Vessels.	*Tons.*
(*a*) Vessels employed in trade between Atlantic ports of the United States and Australia............	79	53,685
(*b*) Vessels employed in trade between Atlantic ports of the United States and Chili............	24	17,120
(*c*) Vessels employed in trade between Europe and Chili............	372	368,193
(*d*) One-half of the tonnage employed between Atlantic ports of the United States and China and Japan—(estimated)............	52	64,604
(*e*) Vessels engaged in guano and nitrate of soda trade between Atlantic ports of the United States and ports of Europe, with the western coast of South America............	810	810,000
Total............	1,337	1,313,602

Deducting the above amount from 2,938,386 tons, he arrives at 1,624,784 tons as representing the probable business of the canal.

The several amounts of tonnage in Table 1, with the exception of 2 and 6, contain items of carriage between ports lying to the north or to the south of Tehuantepec, to be credited to each of the routes, as follows:

Item 1. Traffic over Panama Railroad with San Francisco, (page 19,) 30,734 tons, credit to Tehuantepec.

Item 3. China and Japan trade, 129,208 tons, credit to Tehuantepec.

Item 4. Trade with Brazil and Africa, (appendix 6,) 18,568 tons, credit to Nicaragua.

Item 5. Trade with west coast of Mexico, (appendix 7,) 11,438 tons, credit to Tehuantepec.

Distributing the amounts according to the indications given in the table and correcting as above, the following results are obtained:

	Tonnage for which Tehuantepec would be the shorter distance.	*Tonnage for which Nicaragua would be the shorter distance.*
Item 1	30,734 tons.	502,266 tons.
" 2	120,662 "	——
" 3	129,208 "	118,359 "
" 4	533,361 "	18,568 "
" 5	11,438 "	1,451,459 "
" 6	22,331 "	——
Totals	847,734 tons.	2,090,652 tons.

That is, of the total carrying trade between the Atlantic and Pacific ports, as per Mr. Nimmo's table, five-sevenths would be favored by the Nicaragua route.

Mr. Nimmo made deductions as per Table 3, by which he reduced the probable business of a canal to 1,625,000 tons.

In these deductions one-half the carrying trade between our Atlantic ports and those of China and Japan is included, and in order to ascertain what proportion of 1,625,000 tons carrying business Tehuantepec would favor in distance, that trade must be deducted from the amount above credited to the route:

Proportion for which Tehuantepec was before found to be the shorter distance	847,734 tons.
Deduct half trade with China and Japan (item 1, page 9)	64,604 "
Carrying trade for which Tehuantepec is the shorter route	783,130 tons.
Total Mr. Nimmo's estimated traffic	1,625,000 "
Carrying trade for which Nicaragua would be the shorter route	841,870 tons.

In further discussion of this subject it will be shown that Nicaragua is quite as favorably situated as Tehuantepec for all this carrying business, except that between our own ports on the two oceans and also that between our Atlantic ports and those of the west coast of Mexico.

Assuming this to be the case, the following results are shown by Mr. Nimmo's tables:

	Tonnage via Tehuantepec as the shorter route.	*Tonnage via Nicaragua as the shorter route.*	*Tonnage which might take either route.*
Item 1............	30,734 tons.	502,266 tons.	——
" 2............	120,662 "	——	——
" 3............	——	118,359 "	129,208 tons.
" 4............	——	18,568 "	533,361 "
" 5............	11,438 "	1,451,459 "	——
" 6............	——	——	22,331* "
	162,834 tons.	2,090,652 tons.	684,900 tons.

Or, on the basis of 1,625,000 tons carrying trade—

	Tonnage via Tehuantepec as the shorter route.	*Tonnage via Nicaragua as the shorter route.*	*Tonnage which might take either route.*
Item 1............	30,734 tons.	502,266 tons.	——
" 2............	120,662 "	——	——
" 3............	——	118,359 "	129,208 tons.
" 4............	——	18,568 "	533,361 "
" 5............	11,438 "	138,093 "	——
" 6............	——	——	22,331* "
	162,834 tons.	777,266 tons.	684,900 tons.

Thus it appears that, of the carrying business Mr. Nimmo found for a canal, 162,824 tons would be favored by Tehauntepec; 777,266 tons by Nicaragua, and 684,900 tons, other things than distance being equal, would take either route with like advantage.

The grain carrying from the Pacific Slope would make much larger figures for Item 4, Table 1, than Mr. Nimmo gives, but this business being conducted with European ports would not add a ton to the list *favored by Tehuantepec*, but would pass to the third column above.

The contrast in the ship-railway and canal charges and the effects on the grain-carrying interests of the Pacific States will be considered further on in this paper, as will also the degree to which commerce between our own ports on the two oceans would be favored by the respective routes.

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* Supposed to be with European ports.

[8.]

"Although the estimate of Mr. Nimmo may be fairly criticized for the exclusion of a large amount of tonnage which he assumes will continue to go around the Horn to the eastward, it is probable that the real amount which the line will receive when opened will not exceed three million tons per annum. It is not likely, therefore, that the tonnage crossing the Isthmus within the next generation will support more than one line of ship-transit across it; *and if we are to have moderate tolls, it is imperative that the transit be established upon that part of the Isthmus which will secure the shortest routes for our foreign and coast trade, because every additional mile which the vessel must travel will inevitably add to the cost of transporting the cargo it carries, no matter whether the increased cost results from higher tolls or a longer route.*"

The last part of this paragraph is absolutely meaningless.

[9.]

"*Many persons will be surprised to learn that the Isthmus which connects North and South America is as long as the distance between New York city and the mouth of the Sabine river in Texas.*

"Attention is here called to the accompanying chart. Panama is located *near* South America, and *its distance from Tehuantepec, in Mexico, is one thousand two hundred and fifty statute miles.* Any vessel leaving New York for San Francisco, China, or Japan must have at least that much additional distance added to her passage in the Pacific, *as well as an additional distance in the Caribbean sea,* if she crosses at Panama instead of Tehuantepec, as the Isthmus lies nearly parallel with the route she must traverse. *A steamship from New York or Charleston must travel fifteen hundred miles further to reach her destination than she would if she could cross the Mexican Isthmus.* The cargo which leaves San Francisco for Europe must run the length of the whole Isthmus, and thus be delayed *six or seven days more* than it would be if it crossed at Tehuantepec. Nor can these great delays be saved by the proposed canal at Nicaragua. It will be *about twice as long as the Suez Canal,* and steamships require two days in passing through the latter, although it has no locks. It is fair, therefore, to infer that thrice as much time would be consumed at Nicaragua, inasmuch as a canal there must have numerous locks. *Any attempt to pass these locks rapidly will involve great danger to the lock-gates,* and an injury of that kind may require weeks of delay for repairs. No advantage can, therefore, be claimed for the Nicaragua route over that of Panama, for the canal proposed at the latter place is but forty-five miles long and without locks. *A passage through it could be made in one day, while at Nicaragua the crossing would probably require five or six days.*

"The valley of the Mississippi, so wonderfully productive, with its marvelous net-work of rivers ramifying through every portion of a territory larger than the combined areas of Germany, Austria, France, Spain, Italy, Great Britain, and the Netherlands, and capable of supporting, if peopled as densely as Holland, at least four hundred million souls, has but one natural outlet for its enormous productions—the mouth of its great river. The commerce of this immense region, if it seek a passage to the Orient or California by the Panama Canal, must be diverted out of its direct course a distance almost double the length of the Isthmus. *It must travel two thousand two hundred miles further to reach those markets than by way of Tehuantepec.* These distances are but faintly realized when thus stated, but when the map is measured, and we find that a ship *from New Orleans*

to San Francisco, instead of crossing at Tehuantepec, must go as much farther by the way of Panama as it is from New York city to the eastern boundary of Oregon, every intelligent American must condemn the policy of permitting the transit to be made where it is so manifestly against the commercial interests of his country."

The extreme length of the Isthmus measured along the curves of its axis from the head of the Gulf of Darien to Tehuantepec is 1,230 geographical miles. (See charts U. S. Hydrographic Office; also letters from same office, in appendix.)

The sailing distance, Panama to the Gulf of Ventosa, the Pacific terminus of the Tehuantepec canal survey, is 1,160 miles.

Sailing distances Panama to Ventosa Bay	1,160	miles.
do. do. New York to the Sabine Pass	1,900	"
Error in Captain Eads' statement	740	miles.

Distances New York to San Francisco.

	Distances adopted.	Distances from Report of	Distances from Report of

Errata.—"New York to San Francisco *via* Tehuantepec," in two places, read 4,311 instead of 4,276 miles.

"Difference in favor of Tehuantepec," read 934 instead of 969 miles.

"Error in Captain Eads' statement," read 566 instead of 531 miles.

Distance New York to San Francisco, *via* Panama	5,245	miles.
" " " *via* Tehuantepec	4,276	"
Difference in favor of Tehuantepec	969	miles.
Difference as stated by Captain Eads	1,500	"
Error in Captain Eads' statement	531	miles.

The Suez Canal is 100.15 miles long. Twice this is	200.30	miles.
The Nicaragua Canal proper would be	53.17	"
Error in Captain Eads' statement	147.13	miles.

Again:

Twice the length of the Suez Canal is		200.30 miles.
Total distance across Nicaragua Canal	53.17 miles.	
Lake navigation	56.50 "	
Broad river navigation	63.90 "	
		173.57 miles.
Error of Captain Eads if all were canal		26.73 miles.

* Isthmus transit added.

The river and lake are proposed to be held at one level by a single dam, giving an uninterrupted navigation for 120.4 miles, in which steamers could proceed, night or day, at full speed and make the run in 9 to 12 hours, depending upon their ability, the river becoming, in fact, a broad estuary of the lake.

There are 12 locks and 1 tide-lock, 13 in all. General Weitzel, U. S. Engineer, states (see Appendix B) that he expects to pass steamers through the great Saint Mary's Falls canal-lock in 11 minutes.

The chamber of that lock is 515 feet long, 80 feet wide, and 16 feet deep, and, in his judgment, the steamer *Ville de Paris*, of the Transatlantic line, could be put through a lock furnished with modern improvements in 8 minutes.

At Suez the passage of ships is greatly impeded by strong winds blowing across the canal. No such difficulty can arise in Nicaragua, and four to five miles per hour could be easily made.

Omitting length of locks, there would be 52 miles of canal.

Thus the time for traversing Nicaragua would be—

52 miles of canal, at 4 miles per hour	13 hrs.	0 ms.
13 locks, at 11 minutes per lock	2	23
Lake and river navigation	12	0
Allow for delays, &c	8	37
Total time required for transit, ocean to ocean	36 hrs.	0 ms.

Captain Eads states time required at 5 to 6 days. Error in his statement, 3½ to 4½ days.

Estimated time required by proposed ship-railway route:

35 miles river navigation at 10 miles per hour	3 hrs.	30 ms.
29 " canal " at 4 miles per hour	7	15
*2 locks at 11 minutes each	0	22
110 miles ship-railway at 6 miles per hour	18	20
Allow same detentions as for Nicaragua route	8	37
Total time on same basis as for Nicaragua	38 hrs.	04 ms.

Or more than is required for that route.

Six miles per hour is the railway speed fixed in the bill presented to Congress.

Distance New Orleans to Panama	1,415 miles.
" Panama to Ventosa bay	1,160 "
Distance New Orleans to Ventosa bay *via* Panama	2,575 miles.

* See General Beauregard's letter, dated Jan'y 25th, 1881, published by Capt. Eads in the "Washington Sunday Herald."

Distance New Orleans to Coatzacoalcos river...	802 miles.	
" from the river mouth by proposed ship-railway to Boca Barra....................	174 "	
Distance Boca Barra to Ventosa bay...........	25 "	
		1,001 miles.
Difference in favor of Tehuantepec route......		1,574 miles.
" as stated by Capt. Eads		2,200 "
Error in statement...		626 miles.

Commodore Shufeldt (page 20 of his report) makes the difference in favor of Tehuantepec only 1,400 miles, instead of 1,574 miles, as above adopted.

For sailing vessels all the above distances are less in favor of Tehuantepec on account of the Gulf Stream and prevailing winds. The mouth of the Coatzacoalcos is at the head of the Gulf of Campeachy and on a dead lee shore in northers, making it a dangerous point for vessels in their season.

The prevailing winds in the Gulf of Mexico are easterly, so that sailing vessels have head-winds to work against in voyages to the eastward. The trade-winds and currents favor ships in voyages both to and from the mouth of the San Juan river.

The distance in an air line, New York to eastern boundary of Oregon	2,220 miles.
The distance New Orleans to San Francisco *via* Tehuantepec is shorter than *via* Panama by..	1,574 "
Error in Captain Eads' statement...........	646 miles.

[10.]

"In speaking of the difference in distance by these several routes, reference has been had only to steam-ships. Upon this subject Captain Silas Bent, a gentleman who has devoted much study to the winds and currents of the ocean, and who was formerly an officer of the United States Navy, made the following statement a few days ago before the Merchants' Exchange at St. Louis :

"'Mere statements of the difference in miles is a very inadequate measure of the difference in time that would be occupied by sailing-vessels in making these several passages, and when we consider that three-fourths of the ocean commerce of the world is carried in sailing-vessels, you can see what an important factor this question of *sailing-time* becomes in the solution of the problem before us.

"'The northeast trade-winds which extend across the Atlantic are so broken and interrupted when they encounter the West India Islands, that they never penetrate the Caribbean sea; but the northwest portion of them, however, do extend into the Gulf of Mexico, and often so far down as to reach well toward Tehuantepec, so that whilst in the Gulf winds are always found, yet the Caribbean sea remains a region of almost relentless calms.

"'Nor is this all, for the mountain ranges, extending the length of the

Isthmus of Panama and through Central America, offer a still more formidable barrier to the passage of these winds, thus throwing them still higher into the upper regions of the atmosphere, and extending these calms far out into the Pacific ocean, on the parallel of Panama, with lessening width, for fifteen or eighteen hundred miles to the northwest, along the coast of Central America.

"'This whole region of calms, both in the Caribbean sea and in the Pacific ocean, is so well known to navigators, that sailing-vessels always shun it, if possible, though they may have to run a thousand miles out of their way to do so.

"'This absence of wind of course leaves this vast area exposed to the unmitigated heat of a torrid sun, except when relieved momentarily by harassing squalls in the dry season, and by the deluging rain-falls of the wet season. With these meteorological facts in view, let us now suppose that Lesseps Canal at Panama, and the Eads Railway at Tehuantepec, are both completed and in running order: then let us start two sailing-ships of equal tonnage and equal speed from the mouth of the Mississippi, with cargo for China, one to go by the way of the Panama Canal, and the other by the way of the Tehuantepec Railway, and I venture to affirm that by the time the Panama vessel has cleared the canal and floats in the waters of the Pacific, the Tehuantepec vessel will have scaled the Isthmus and be well on to the meridian of the Sandwich Islands; and that before the former vessel can worry through the fifteen or more hundred miles of windless ocean before her, to reach the trade-winds to the westward of Tehuantepec, the latter will have sped five thousand miles on her way across the Pacific, and be fully thirty days ahead of her adversary. For it is a fact worth mentioning here, that the strength of the northeast trade-winds in the Pacific, as well as the maximum strength of the northern portion of the great equatorial current in that ocean, are both found on or near the parallel of latitude of Tehuantepec, the former blowing with an impelling force toward the westward of ten or twelve miles an hour, and the latter with a following strength of three or four miles per hour.'"

If Captain Eads will consult the following authorities, he will discover that Captain Silas Bent fell into most unaccountable errors in his letter, as quoted above, in regard to the winds in the Caribbean sea, Gulf of Mexico, and Pacific ocean.

Wind and Current Charts U. S. Hydrographic Office, 1872.

Meteorological Charts, Depot des Cartes and Plans, Paris, 1874.

Current Charts English Admiralty, 1872.

U. S. Hydrographic Office Charts, Pacific Ocean, 1877.

M. F. Maury, Wind and Current Charts, N. Atlantic.

3d Ed. No. 1 Series A, 1848.

General Examination of North Atlantic Ocean by C. P. de Kerhellel, translated by Captain Wyman, U. S. N., 1870.

Navigation of N. Atlantic Ocean, F. Sabrone, translated by Lieut. Coghlin, U. S. N., 1873.

These authorities show (1) as regular trades in the Caribbean sea as any where in the N. Atlantic ocean, and thousands of passengers who have suffered sea-sickness in the voyages to and from Aspinwall can attest to their strength; (2) that the winds

in easterly voyages from, and the currents in westerly voyages to the Coatzacoalcos river, are aganst vessels, and (3) that in the Pacific ocean for half the year, both winds and currents favor vessels in voyages to the North Pacific from Nicaragua as compared with Tehuantepec. During this season entire calms or northers prevail in the Gulf of Tehuantepec.

In outward voyages to Nicaragua from Europe vessels can closely follow a great circle, which passes by the eastern end of Cuba, with fair winds, and, returning, they have fair winds and currents around the western end of Cuba to the Gulf Stream, while vessels from Coatzacoalcos would reach that meridian by working against head-winds.

[**11.**]

"In considering this important question from a military point of view, the superior advantages possessed by Tehuantepec over Panama and Nicaragua will be apparent to anyone who will examine the map. A few iron-clads and torpedoes placed in the narrow channel between Yucatan and Cuba, and as many more in the Florida channel, would defend the entire Gulf of Mexico against almost any naval force that could be concentrated in them, while it would be simply impossible to isolate as completely the Caribbean sea with ten times as many iron-clads. *It would be almost impossible for the United States to hold the Panama or Nicaragua canal against such a naval force as either France or England, with its present navy, could bring to bear against it.*"

Captain Eads evidently forgot several things: That the United States have no iron-clads; that his railway could be approached on the Pacific side as well as on the Gulf side, and that, if what he says about blocking up the Gulf of Mexico be true, no such thing could be done for the Gulf of Tehuantepec.

In truth, the United States, with their present preparation, could not keep iron-clads out of the harbors of New York or Boston, much less out of the Gulf of Mexico.

[**12.**]

"Two very important railroads are now being rapidly constructed in Mexico by American companies: one extending from Texas, and the other from New Mexico, to the city of Mexico. A very superior railroad is already built from the city of Mexico to Vera Cruz. *This latter city is only one hundred and nine miles from the mouth of the Coatzacoalco River*, which will be the entrance to the ship-railway. A railroad from Vera Cruz toward the mouth of the Coatzacoalco has already been commenced. By these railroad lines, a very large body of troops could be rapidly concentrated in Tehuantepec to protect the works against a hostile land attack. The gulf end of the railway would be at least thirty miles in a

direct line from the gulf coast, and the Pacific terminus of the road would be fourteen or fifteen miles from the Pacific coast. Both ends of the road would, therefore, be beyond the reach of the guns of an enemy's ship, unless it entered through the Coatzacoalco river or the jettied channel of the lagoon on the Pacific side—both of which channels could be easily and cheaply defended by torpedoes. In addition to this, the ship-railway would be located on the territory *of a powerful and friendly republic, whose history has not only proven its aversion to European domination, but has shown its power to deal successfully with an invasion of its territory. We have, therefore, the assurance that Mexico itself is able to protect, very effectually, the ship railway, without the aid of any other power.* On the other hand, we have no assurance that the interests of the small and much less powerful states of Nicaragua and Columbia would not be enlisted in favor of European intervention. It is not many years since a convention was concluded between France, England, and Nicaragua, by which the integrity of Nicaragua was guaranteed by its two powerful allies."

The distance from Vera Cruz to the Coatzacoalcos river, as above given, is erroneous.

In an air line the distance is	145 miles.
Distance stated above	109 "
Error	36 miles.

But a railway would be much longer than the air-line distance.

There is also grave error as to facts in the historical references.

General Scott captured the city of Mexico with a command hardly equal to a full division in one of our army corps during the civil war.

The French made Maximilian Emperor of Mexico with 30,000 men, and would have sustained him but for the attitude of our Government and the presence of General Sheridan with 75,000 veterans on the line of the Rio Grande.

These events do not indicate that power to protect the proposed ship-railway which is claimed for Mexico.

[**13.**]

"It would be idle to undertake to defend a canal at Nicaragua or at Panama with American troops, because of the difficulty of sending them overland to either point, and of maintaining them in such an unhealthy region, and so far from any available base of supplies. This difficulty would be greatly enhanced if it should happen that the citizens of either country favored such European intervention as the United States would feel compelled to oppose."

Any one who knows anything whatever of the subject is aware that Tehuantepec has no claim whatever to superiority in salubrity of climate over Nicaragua.

They are both healthy, for tropical regions, but along either route the utmost care will be needed to maintain a working force in fair condition of health.

[14.]

"If *a canal* were equally practicable at Tehuantepec, *no intelligent American would hesitate a moment to give it the preference over any other route.* But are the immense natural advantages of that location to be disregarded because a canal cannot be used, when *the most eminent ship-builders* and *many of the ablest engineers in the world* do not hesitate to declare in print, over *their own signatures*, that a ship-railway is not only practicable, *but that it is really better than a canal; that it is much cheaper to build; that it can be more quickly constructed; that the largest ships can be transported much more rapidly and with equal safety on it*; *that it can be more easily enlarged to meet the future demands of commerce, and that its maintenance will be less costly?*

"But, say some, 'You cannot transport ships by rail without straining them. It is impossible to take a laden ship out and put it upon a dry-dock without removing her cargo. It will burst her sides out, and she will be bent and strained while in transit over the railway.' *These objections are advanced by men who have not studied the principles of ship-building or engineering, and who are therefore not competent to form a correct judgment on the subject.* The captain of an ocean steamer and the engineer who plans and builds her follow professions that are widely different. The engineer would be as unfitted to command and navigate the ship as the captain would be to deal with the mathematical processes by which the materials in her hull and engines are proportioned to bear the various strains which each particular part must resist. Men who are competent to investigate and determine the infinite variety of strains which the boilers, engines, propeller, shaft, and various parts of the ship must bear while the vessel is *plunging, twisting, and bending*, under the fury of a storm, are certainly competent to pronounce upon the practicability of transporting her upon a well-built railway. There is no lack of testimony from men of this kind in favor of it. But the transportation of vessels upon a railway is by no means an untried experiment, and therefore it is not wholly dependent upon the opinion of experts."

These two paragraphs require consideration together, and at some length. In the Appendix will be found the opinions of ship-builders in the United States.

The list embraces, besides other builders, every builder of iron ships but one in this country, that one having as yet failed to respond.

These men are John Roach, Wm. H. Webb, Nathaniel McKay, C. H. Mallory, T. F. Rowland, Messrs. Harlan & Hollingsworth, Pusey, Jones & Co., the managers of the Atlantic Iron Works, and of the Delamater Iron Works.

In the Appendix will also be found the opinion of Wm. J. McAlpine, who stands very high in his profession, and is preeminent in hydraulic engineering, and, also, a discussion of the ship-railway question by Mr. A. Savary, justly esteemed as a high authority.

These are the men who have not studied the principles of ship-building or engineering, and are, "therefore, not competent to form a correct judgment."

It would have been wise had Captain Eads given the names and quoted from the opinions of the most eminent ship-builders and engineers who, according to his assertion above, think his proposed railway "better," "cheaper," "more safe," "more economical," and "more cheaply maintained than a canal."

Mr. Reed, an English naval constructor, whose letter was in part quoted by Mr. Eads, in a letter to the Hon. J. Floyd King, in no sense endorses the Captain's plan, but refers to arrangements employed in England for raising and lowering canal boats by pontoon-tank, similar to, but not so large, as that in use above Georgetown—the vessels to be kept afloat—and writes, "I "am satisfied that by modifying the plans of these hydraulic "operations and greatly augmenting their scale, &c.," showing that he had in view ships carried by tanks and not unsupported by water as Captain Eads proposes. Without that feature the operation ceases to be hydraulic in character.

Moreover, Mr. Reed had in view such a tank for use at Panama, contrasting its difficulties and cost with a canal as projected there, which, although only 45.3 miles long, cannot cost less than $500,000,000, even if practicable at any cost. He did not have in view Tehuantepec, which is 143.5 *miles across in an air-line* and 754 feet in elevation, and contrast that route with a canal only 53.17 miles long, with no heavy cuts, no drainage lines to contend with, an abundant supply of clear water, and only 109.10 elevation to overcome.

I will not waste time upon a letter of Mr. Hart, published by Capt. Eads. These are his ship-builders.

He quoted Mr. Chanute and General Gilmore as engineers. An examination of the letters of these gentlemen will show that the writers had no knowledge whatever of the proposed route, and had made no study of the subject. They did not pretend to assert more than the opinion that, under certain conditions, ships could be transported by railway. Captain Eads has since

published a letter from General Beauregard, which is simply a quotation from the Captain's letter to him, and a general acquiescence in what was therein presented. There is no evidence of any knowledge of the subject, and the General even adopts the most patent errors in Captain Eads' statements.

So much space is given to this matter because there is no publication by Captain Eads of any statement made by an engineer or ship-builder that evinces a study of the general problem presented, one including many questions besides that of the mere possibility of hauling a ship over a railway.

This will be again referred to in these comments.

[**15.**]

"Within four miles of Washington, a railway, composed of four rails, transports canal-boats from the Potomac river to a canal which is about thirty feet above it. The boats are conveyed over the railway several hundred feet to the other level. The total load each trip weighs about three hundred tons. The canal-boats are carried in a tank of water* about seven feet deep, yet the water does not burst out the sides of the tank, although there are no beams across the top of it to tie its sides together. Ships have their sides strongly tied together by their deck-beams, and they are rarely more than seven feet between decks. There is no cargo which will tend to burst out the sides of a ship more than that of grain in bulk, and grain is not as heavy as water. Consequently the ship's sides have the advantage of the canal-boat tank in the fact that they are strongly bound together by the deck-beams, whilst the tank has nothing at all comparable in strength to sustain its sides. There is no sea-worthy iron or wooden vessel afloat upon the ocean whose sides are not sufficiently strong to resist bursting, if the vessel were put in a dry-dock and filled with water to her main deck, and this would be a much greater internal pressure than any cargo could create."

Captain Eads is not fortunate in his reference to the railway, as he terms it, to transfer canal boats between the Potomac river and the Chesapeake and Ohio Canal.

It is like its prototype in England to which Naval-Constructor Reed referred in a letter before mentioned—intended to retain vessels afloat by use of pontoon or water-tank mounted on wheels, and serving as the transporting car or carriage. It is a canal incline—nothing more. But it affords some instructive lessons.

There are four tracks laid upon stone foundations, *built up from the solid rock below*, and carefully filled in. On these stone

* I do not approve of the plan of carrying vessels in tanks of water, over long distances, as it involves the cost of carrying a great weight without compensation.

walls oak timbers, "6 by 12 inches," are laid in cement and bolted to the cross-ties, which are let into the stone walls, and heavy steel rails are spiked upon the timbers.* These tracks, laid at the uniform angle of 1′ in 12′, are made as true a plane as possible, and built with the utmost care. Upon either side are tracks at an angle of 1′ in 10′, on which move cars loaded as counter-weights to balance the weight of the loaded pontoon, so that the machinery has only *friction to overcome.* As each counter-weight carries the movable single block of a "two-single block-purchase," the fall end of which is attached to the pontoon, the weights move through half the distance passed over by the pontoon. A flexible steel wire rope, 2¼ in. in diameter, is used, and the pulleys are of very large diameter, while the purchase is such that the strain falls upon six parts of the rope.

The power applied is a stationary one, consisting of a 200-horse-power turbine wheel, and is transmitted to the pulleys by gearing.

The pontoon is 112 feet long and 16 feet wide, (15 inside,) is mounted on 36 wheels, 9 to each rail, and is adjusted to retain a perfectly horizontal position.

The canal-boats are 90 feet long, 14 feet wide, 6 feet deep, and draw 4 feet and 4½ feet of water. Their weight, loaded, is about 140 tons.

The pontoon, boat, and water to float it, weigh 400 tons, covering 1,792 square feet area, and giving a pressure of 516 pounds per square foot.

At first a steel wire rope, two inches in diameter was used. This rope was so arranged that the pull fell upon 6 parts of the rope, but it broke and some employés were killed.

A 2¼ inch rope was then substituted. The power was found insufficient *to overcome the friction,* and after repeated trials, the *use of water was abandoned* for loaded boats, but empty boats are taken in about 20 inches water.

The result of omitting the water is told in the Appendix D; boats are strained, spring leaks, &c.† Yet the pontoon moves through only about 500 feet space, and at a speed extremely

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* The President of the Canal Company states that the best steel rails obtainable are crushed by the weight. S. L. P.

† An employé at the incline admitted that boats had sprung leaks. S. L. P.

small compared with what Captain Eads proposes for his ship-railway.

Canal boats are much alike, are all flat-bottomed and shallow, and as little like a ship as a dry-goods box.

If any kind of craft could endure the effects of a heavy strain upon the car on which it is being carried, a canal-boat should be one of them.

The unexpected amount of friction encountered is referred to in the letter in the Appendix marked E.

There are bearings upon both sides of each wheel, and the reason for the enormous expenditure of power to overcome the resistance has not been ascertained. But, if 400 tons create such difficulties when a stationary power is used, what may we not anticipate when the weight of the ship and car is 10,000, 15,000, 20,000, and 26,000 tons, to be drawn by traction engines?

There is another feature worthy of attention. All the oak timbers laid in cement along the carefully levelled stone foundations were being replaced when the incline was visited.

Those removed had been *shivered*, although the steel rails laid on these timbers are of heavy character and the movement over them is a slow one.

The experience of the engineer at the incline has not made him an advocate for the ship-railway project.

Captain Eads' assertion as to what a ship can endure are not likely to be verified, as no owner would allow one to be filled with water when in dock. But even if one were to sustain the strain of being filled with water when at rest in dock it would furnish no evidence of its sufficient strength when suffering from vibrations, unequal supports, and strains of varied character while moving at the rate of six miles per hour.

Reference has been made to a *ship-railway* (as it has been styled) in Germany, and Captain Eads has displayed wood-cuts and photographs representing it.

It is presumably the transfer-road for vessels of 60 *tons* from the upper to the lower part of the Elbing Overland Canal in West Prussia.

It is an incline, in fact, and bears in magnitude to Captain

Eads' projected ship-railway about the relation a baby-carriage would to an express train of Pullman cars.

[16.]

"If it be supposed that the ship will be bent in the direction of her length, we have only to inquire into the pressure which the vessel and car impose upon the road-bed to have such fear banished at once. *Trains of one thousand tons weight are not uncommon upon ordinary railways. I have been assured by a gentleman of great experience* in railway management that he has seen a freight-engine, *of the Mogul pattern*, haul *one train of eleven hundred tons on the Illinois Central railroad. If six such trains were placed side by side, they would represent the weight of one of the very largest steamers when loaded. There would be no fear of the ground giving way beneath these six trains, although a large portion of the earth under them would sustain no portion of the load when at rest*, because each end of an American railway car rests on a truck with four wheels, while *fifteen or twenty feet* of the road under the middle of each car has *no load whatever upon it.* No wheels are placed under this part, as they would interfere with the passage of the car around curves; but as the ship-railway will be *absolutely straight*, the wheels can be placed as close together under the ship as they are at each end of the car."

On the Baltimore and Ohio railway a carload of wheat is stated to be 400 to 450 bushels, weighing 24,000 to 27,000 pounds; weight of car 19,000 to 22,200 pounds.

Hudson River Railway platform cars, loaded at the White Star Company's dock, in New York, carried each 42 steel rails, weighing 26,880 pounds. Weight of cars 17,000 to 19,000 pounds. These freights probably give as high an average as any, and show for weight of freight and car about 20 tons.

A train of 1,000 tons weight would be represented by 50 *loaded cars*. It is safe to say no one ever saw a single locomotive hauling 50 loaded freight-cars for a distance over varying grades on any road in the United States. Perhaps on level or descending grades such a train might be moved.

Table showing the effective hauling capacity of engines of 27 *tons weight.* (*See Appleton's Encyclopedia of Applied Science, Ed.* 1880.)

For level grade	729	to	892	tons.
" 10 ft. per mile ascending grade	469	"	626	"
" 20 " "	343	"	454	"
" 30 " "	268	"	358	"
" 40 " "	218	"	292	"
" 50 " "	183	"	244	"
" 70 " "	137	"	184	"
" 100 " "	97	"	130	"
" 120 " "	79	"	106	"

Is there any long line of road in this country without a grad-

ient of 20 feet per mile? For this rise the theoretical traction power of the engine is 536 tons, but its effective work is only 343 to 454 tons.

Captain Eads states that six of these 1,000 ton trains, side by side, "*would represent the weight of one of the very largest steamers when loaded.*" "There would be *no fear of the ground giving way beneath the six trains,*" &c. How little care and thought he had given!

The weight of both cars and freight is included to make up 1,000 tons, and assuming each car to occupy 35 feet in the train, 50 cars would extend along 1,750 *feet of track.* Six such trains, side by side, would cover each of the six tracks 1,750 feet. The steamship *Colon* weighs with cargo 3,740 tons, and is 280 feet long by 40 feet beam. The ship-car, with cradles and supports, would weigh probably as much as the ship carried, making the whole load 7,480 tons, while the car, according to the plan proposed, would be 180 feet by 40 feet wide.

Therefore Captain Eads' 6 trains of much less weight would cover 1,750 feet of six tracks, while the ship-car would cover but 180 *feet of six tracks.*

The comparison is consequently erroneous and absurd.

The *Colon* is by no means a large vessel, but Captain Eads appears to have erroneous ideas, concerning the weight of ships, as will be seen by the following table:

Dimensions and Weight of some Steamships.

Name.	Length. Keel.		Over all.	Beam.		Draft.		Gross Tonnage.	Displacem't.	Cargo Carrying Capacity.	Owners.
	ft.	*in.*	*ft.*	*ft.*	*in.*	*ft.*	*in.*				
Tokio and City of Peking..	423		...	48		24	6	....	9,000	4,050	P. M. S. S. Co.
Germanic……… / Britannic………	455		...	45		26		5,000	10,000*	4,300	White Star Co.
Gallia………	430		...	44		25		4,809	8,800	………	Cunard Co.
Arizona………	450		...	45	4	26		5,100	10,000	………	Guion Co.
Egypt………	440		...	44		25	6	4,670	9,160	………	National Co.
City of Berlin………	489		513	45		26		5,491	11,050	………	Inman Co.
Servia………	525		...	52		26		8,500	13,182	6,500‡	Cunard Co.
City of Rome………	546		600	52	3	26		......	13,500†	………	Inman Co.
Longhirst………	285		...	36	2	22	6	2,093	4,310	………	English
Colon………	280		...	40		20		......	3,740	………	P. M. S. S. Co.
Bucentaur………	282	3	...	33	3	22		1,765	3,834	………	English.
Felicia………	236		...	31		16	5	....	2,242	………	"

* Obtained from the builders' scale at the White Star office, N. Y.
† Stated by builders, Barrows Ship-building Co.
‡ Stated by builders, Messrs. J. and G. Thomson.

The displacements not taken from builders' publications are computed for hulls of the same model as the *Germanic*, and will be sufficiently exact.

The *Pavonia* and *Parisian*, each of 5,500 tons gross measurement, should displace over 10,000 tons.

The *Auronia*, 7,500 tons, should displace 12,000 tons.

The *Alaska*, 6,400 tons gross, will displace over 11,000 tons.

The hull of the *Servia*, without machinery, weighs 5,200 tons, and will carry altogether 6,500 tons weight, cargo and supplies.

The *City of Rome*, ready for sea, without cargo, weighs 8,000 tons, and will carry *dead weight of cargo* 5,500 tons.

The *Tokio* carries of dead weight 4,050 tons.

The *Germanic's* hull and machinery weigh 5,500 tons, and she carries cargo and supplies, 4,500 tons.

The White Star Company is building larger steamships, and it will be seen that the tendency is to build larger ships; such a condition must be met by the proposed ship-railway.

Dimensions and Tonnage of War Vessels.

NAME.	Length.	Beam.		Draft.		Displacement.	Nationality.
	Ft.	*Ft.*	*In.*	*Ft.*	*In.*	*Tons.*	
Inflexible*	320	75		24	6	11,409	English.
Ajax*	260	66		23	6	8,492	do.
Gorgon	225	45		16	5	3,430	do.
Temeraire	285	62		25	9	8,412	do.
Glatton	245	54		19		4,912	do.
Shah †	335	52		23		6,040	do.
Cleopatra †	225	44	6	20		3,383	do.
Devastation	372	66	5	23	10	9,630	French.
Tonnere	242	57	9	21		5,495	do.
Refuge	130	51	10	10	6	1,422	do.
Italia	394	73	10	30	4	13,489	Italian.
Duilio	340	64	7	25	11	10,650	do.
Varesc	198	42	4	13		2,700	do.

* Ships of these classes carry turrets and castles in the midship sections, in length from 104 to 110 feet; consequently, the principal weight is embraced in that part of each such ship.

† Not armored. United States cruisers will range with the Shah and Cleopatra in weight.

The *City of Rome*, equal in weight to the *Italia*, is 546 feet long on the keel and 52¼ feet wide, while the *Italia* is only 394 feet long, but is 73 feet 10 inches wide. The *City of Berlin* is 489 feet long and 45 feet wide, while the *Inflexible*, of a similar weight, is 320 feet long and 75 feet wide.

The *Colon* is 280 feet long and 40 feet wide. The *Gorgon* is

is 225 feet long and 45 feet wide, while the *Glatton*, only 245 feet long, has 54 feet beam and weighs about 1,200 tons more than the *Colon*, and only 600 more than the *Longhirst*, 285 feet long by 36 feet beam.

These comparisons show that Captain Eads' apprehensions for the capture of his ship-railway are not well founded, as the tracks and cars constructed for carriage of merchantmen would not serve to transport armored war vessels.

The voyages between Atlantic and Pacific ports are of great length, requiring, for economy, steamships of the largest class, and the ship-railway to be a success must be built to carry them.

A railway proportioned to bear a ship weighing 10,000 tons would not take the one weighing 12,000 tons, nor will a road intended to carry only 1,000 tons take 2,000 tons.

It must be constructed for the longest and widest ship to be transported and yet be adapted in some wise for those of less length and width.

The Captain proposes an overhang of 50 to 60 feet at each end of the ship-car, in order to counterbalance the greater weight of the middle sections of ships as compared with their extremities. To accord with his plans an overhang of 50 feet will be herein allowed in all cases. Each car mentioned will, therefore, be 100 feet shorter than the ship it is supposed to carry, unless it be otherwise stated.

Thirteen thousand tons are to be transported. The car for the *City of Rome* would be 446 feet by 52¼ feet; that for the *Servia* 430 feet by 52 feet, while the car for the *Italia* would be 294 feet by 74 feet.

For the first of these vessels the car would cover 23,303 superficial feet; the weight upon it being 13,000 tons, (the builders' weight is 13,500,) the pressure would be 1,245 pounds on each square foot of car, and 2,490 pounds on the tracks, since the weight of car, &c., will probably equal the weight of ship.

For the second the pressure on car would be 1,389 pounds, and on the tracks 2,778 pounds per square foot.

The car for the *Colon* would be 180 feet by 40 feet, equal to 7,200 square feet area.

The weight of ship and cargo is 3,740 tons, giving 1,165

pounds per square foot on the car and 2,230 pounds on the tracks.

Captain Eads compares this pressure on the tracks to that of railway trains.

The platform cars carrying 12 tons of railway iron are 32 feet by 8 feet, equal to 256 superficial feet, giving a pressure of 105 pounds per square foot of car.

The pontoon at the Georgetown incline was designed to carry a load of 260 tons.

It. is 112 feet by 16 feet, equal to 1,792 square feet, and the weight carried is 325 pounds per square foot. But as the 200-horse-power machinery could not overcome the friction of quiescence, no water is now used, and the load consequently is about 140 tons, or 175 pounds per square foot.

Thus the comparison stands:

Weight per square foot carried on the ordinary freight car.........	105 lbs.
" " " " pontoon at Georgetown....	175 "
" " " " " " with water...	323 "
Weight per square foot carried on the ship-car for the *Colon*.......	1,165 "
" " " " " *City of Rome*...	1,245 "
" " " " " *Bucentaur*......	1,470 "

The weight to be carried in case of the ships is 12 times greater than upon the ordinary car.

The pressure upon the road-bed would be about twice the above amounts, except for the "incline," where, when carrying water, the pressure is 506 pounds per square foot of road-bed, the pontoon weighing from 120 to 140 tons.

Were the railway car loaded in the same degree as the car for the *Colon*, it would carry 133 tons instead of 12; and were the weight of the platform car then in the same proportion to freight it now is, it would weigh 89 tons!

Captain Eads' statements, therefore, as respects pressure upon the road-bed, are entirely incorrect.

If a car to bear 105 pounds per square foot of surface must weight 8 to 10 tons, what must be the proportionate weight of one to carry 1,245 pounds per square foot under circumstances preventing the use of pivoting centres and all the devices known upon car trucks? It is at least safe to assume the weight of car, cradles, and supports equal to the load carried. It would be

unsafe to assume a lesser weight in the absence of positive information gained by experience.

While it is true that the 20 tons weight of car and load, in the ordinary freight car, rests on 8 wheels, a middle section of the car unsupported by wheels—it is equally true that the heavy metal rails resting on cross-ties distribute the weight they carry over several feet upon either side of the space covered by the trucks. Therefore Captain Eads' statement that 15 to 20 feet space bears no load whatever, is incorrect.

The entire load, car and freight, give but 2½ tons pressure upon each of the 8 wheels of a freight car. Why are not heavier loads carried if the wheels can bear 15 to 20 tons each in safety? The captain knows perfectly well there are sound reasons for the limited load.

Such frequent mention is made by Captain Eads of the pressure upon the wheels of his proposed ship-car that for convenience in future references in these remarks the following tables have been prepared, They are based on the weights and dimensions of ships already given.

The cars are assumed to allow 50 feet overhang for each class of vessel according to Captain Eads' plan, although it is an absolute violation of every mechanical law to assume such an abitrary number of feet, and shows great carelessness in the study of the subject. Fifty feet overhang at each end of a car for a ship 500 feet long is 20 per cent. of the ship's length, while for one of 250 feet in length it is 40 per cent.

His purpose is to equalize pressure upon the wheels, the middle sections of the ship being much heavier than the ends, but the pressure on the central part of the car would be virtually the same, whether the car be the length of the ship or shorter by 20 to 30 per cent. The longer car would have more wheels but the *weight of the light extremities of vessels* would be *distributed over the additional wheels*, not that of the weightier central portions.

In other words, the number of rails required to receive the wheels necessary to maintain the load for each in all the central portions, at not exceeding 5 tons when at rest, would not be reduced by lengthening the car, provided the original length be proportioned to that of the ship carried in such manner that the

whole weight is equally distributed on the wheels. The dangers to be apprehended from the overhang are independent of the simple question of the load upon each wheel. In general terms, the model of the present style of iron steamships is from 60 to 65 per cent. of the containing parallelopiped, the sides of which are equal to the length on keel, breadth, and depth of the vessel, and this ratio might serve for computing the length of car proper for the particular vessel to be carried in so far as respects equal distribution of weights.

Pressures upon Wheels.

Weights of ships:

	Length.	*Beam.*	*Weight loaded.*
a City of Rome, (Servia,)	546 ft.	52 ft. 3 in.	13,000 tons.
b City of Berlin, (Alaska,)	489 "	45 "	11,000 "
c Tokio, (Gallia, Egypt,)	423 "	48 "	9,000 "
d Colon, (Longhirst,)	280 "	40 "	4,000 "
e Felicia	236 "	31 "	2,240 "

Pressure per wheel for weight of ship only upon a car according to Captain Eads' plans.

a Car,	446 feet;	number of wheels,	1,788;	at 7	tons each	12,516 tons.
b "	389 "	" "	1,560;	" 7	"	10,920 "
c "	323 "	" "	1,296;	" 7	"	9,072 "
d "	180 "	" "	720;	" 5.5	"	3,960 "
e "	136 "	" "	540;	" 4	"	2,160 "

Pressure per wheel, car, cradles, &c., equal to one-half the *weight of ship:*

a Car,	446 feet;	number of wheels,	1,788;	at 10.75	tons each,	19,221 tons.
b "	389 "	" "	1,560;	" 10.5	"	16,380 "
c "	323 "	" "	1,296;	" 10.3	"	13,349 "
d "	180 "	" "	720;	" 8.5	"	6,120 "
e "	136 "	" "	540;	" 6	"	3,240 "

Pressure per wheel, car, cradles, and supports, *equal to* weight of ship:

a Car,	446 feet;	number of wheels,	1,788;	at 14.5	tons each,	25,926 tons.
b "	389 "	" "	1,560;	" 14	"	21,840 "
c "	323 "	" "	1,296;	" 14	"	18,144 "
d "	180 "	" "	720;	" 11	"	7,920 "
e "	136 "	" "	540;	" 8	"	4,320 "

[17.]

"In the ship-railway cars the wheels will be two feet in diameter, and will be placed *three feet apart on the rails.* It must be evident that if we place *as many wheels under the ship as are required in the six railway trains just referred to, the ship may be of a weight equal to them, without imposing any more pressure upon the rails at each point of contact than is imposed upon the wheels supporting the six railway trains. The pressure* of the

driving-wheels of a locomotive at rest is *about six and one-half tons for each wheel. The pressure on the ship-railway will be limited to five tons per wheel.* The rails and wheel will, however, be quite capable of bearing twenty tons on each wheel, and, to provide for any inequality in the rails, steel springs will be placed over each wheel. As each one of these wheels will have an independent axle, and be disconnected from any other, the derailment of the car will be almost impossible. An additional safeguard against derailment will be found in the slow rate of speed, (eight or ten miles an hour,) and in the fact that each division of the road will be straight. *Turn-tables, long enough to carry the ship and car, will be placed where a change of the direction in the road becomes necessary.* By this means the car and its burden may be turned to correspond with another straight reach of track. From the surveys thus far made it is not anticipated that more *than three of such turn-tables will be required* on the entire line of road."

Assuming freight cars and their loads to weigh 20 tons and to occupy 35 feet in a train, 1,300 cars would represent the combined weights of the *City of Rome* or the *Servia*, and of a ship-car 450 feet long by 52 feet wide and its equipments.

This line of cars would extend 8.6 miles and would have 10,400 wheels, which, placed at 3 feet centre to centre, would require 31,200 feet of rails, or 69.3 rails each of 450 feet in length.

At 5 tons pressure per wheel the number necessary for the ship-car would be 5,200, and they would require 15,000 feet of rails, or 34.7 rails each of 450 feet in length.

Captain's Eads' plans contemplate the use of only 12 rails with a limit of 5 *tons pressure* to each wheel, while the number of rails necessary to take the wheels is nearly 3 times greater. Without including the weight of cars, the number of rails required for the *City of Rome* would be 17¼. Selecting the *Ajax* as a medium sized vessel of war, we should have a car 160 feet long, covering 10,560 square feet, the total weight being 16,984 tons. This gives weight upon car 1,800 *pounds per square foot* and *the weight upon the track* 3,600 *pounds per square foot.*

At 5 tons per wheel the number necessary would be 3,399, requiring 10,197 feet of rails, or 63 rails of 160 feet in length, more than five times the proposed number, and they would be about one foot apart for the width of the ship.

The overhang he proposes at either end would become a source of certain disaster wherever there should be any change in the grade or inequalities in the tracks. Flexibility in the ship itself, such as Captain Eads describes in (19,) would produce the same results, that is to say, to bring upon the wheels at one or both ends a crushing load.

A change in gradient would throw the weight of the ship wholly upon the car ends or upon the car centre, depending upon the change being to an ascending or descending grade.

In the former case, besides suspending the ship upon the car ends, the overhang whether the ship should bend or not, would become an enormous lever to work destruction to the car.

The same effect would arise in variations in points of support due to deviations in the tracks from a true plane, and also if there were any degree of sagging in the extremities of the ship.

Engineers are familiar with the devices resorted to in railway cars to maintain a bearing upon each wheel under the car, which is rendered possible by the manner in which the load is carried upon two centres, each of which is in the centre of a system of trucks having 4 wheels.

But for this construction only 4 of the 8 wheels would momentarily carry the load. A ship-car would offer insuperable difficulties to such inventions and the weight would be carried practically, as in all other bodies moving on wheels, on 4 points. The weight might be distributed by a strong and rigid car for a short distance about those ever-changing points, but it would be borne by few wheels, because a perfect plane can nowhere be maintained on a railway track.

Under this rigid ship-car the wheels must be rigidly fixed. There can be no freedom in movement as experienced under the freight car, and springs could hardly be adjusted to meet the changes which make a wheel bear all the weight or none, as the case might be.

The following are the pressures upon the driving-wheels of locomotives, taken from "Appleton's Encyclopedia of Applied Sciences," edition 1880:

	Pounds.
2 engines, models by Grant, each	10,500 10,500
1 engine, models by Baldwin, *Mogul* included	10,500
1 " models by Baldwin, *Mogul* included	9,000
1 " models by Baldwin, *Mogul* included	11,000
1 " models by Hinckley	10,250
" models by Hinckley	12,000
1 " by Danforth	10,804
1 " by Frank	11,000
1 " by Rogers	10,000
1 " by Mason	11,000
Average	10,550
Or in tons	4.7

The greatest pressure is upon the driving-wheels of the Hinckley engine, viz., 12,000 pounds, or 5.35 tons.

	Tons.
Pressure stated by Captain Eads	6.5
Average pressure	4.7
Error in statement	1.8

A careful reading of the surveys made by General Barnard and Commodore Shufeldt do not hold out a hope that "3 turn-tables," nor 3 times 3 of them, would suffice for changes in direction in that mountainous country.

What an affair one of these turn-tables would be! Strong enough to carry its own weight and 26,000 tons. How many wheels would it require at 5 tons pressure each?

The whole weight to be turned about would be more than 100,000,000 pounds!

One is lost in the contemplation of such prodigious weights—a weight nearly equal to that of the Washington Monument completed and made 550 feet high.

[18.]

"A misapprehension exists regarding the danger of bending the ship where a change of grade becomes necessary. *At Tehuantepec one foot in one hundred will be the maximum.* From a horizontal plane to this grade the change can be made so gradual in the distance of one mile that a ship *four hundred feet long would not be bent one inch out of a straight line* if it conformed to the vertical curvature of the track. But the springs under the car will prevent even this little bending."

Profile maps accompanying the reports of surveys of the Isthmus of Tehuantepec, by General Barnard, U. S. Engineers, for a railroad, and of Commodore Shufeldt, U. S. Navy, for a ship-canal, (see their reports,) indicate that a gradient of 113 feet per mile may be obtained upon the western side of the Isthmus.

In this section General Barnard, by following a tortuous mountain stream in the descent to the Pacific plains, obtained a gradient of 55 feet per mile for 10 miles running distance, gaining in a right line hardly half as much, and showing an average descent of surface of 110 feet per mile.

In another pass Commodore Shufeldt located the canal upon a sharply curved line sweeping along the slopes of the elevated range, and in a distance of 8 miles located 63 locks of 10.14 feet

lift, showing a gradient of 80 feet per mile on the projected line. No reductions in inclination can be effected in the ship-railway track as in the common railroad or ship-canal, by gaining distance through circuitous lines.

The ship-railway must be absolutely straight, and changes in direction by means of turn-tables cannot be effected on precipitous slopes. Had there been better gradients anywhere it is not to be presumed those officers would have selected the routes they adopted; consequently, whatever may be asserted to the contrary, actual surveys, plottings, and profiles will be necessary in proof that easier gradients can be found. Until that is done we must rightly assume that the ship-railway would encounter in a straight line the same differences in elevation which it was proposed to overcome by a highly tortuous track in the case of the ordinary railway and by a long curve in the case of the ship-canal. It may be well, also, to observe that 63 locks of 600 feet in length could not be constructed in the distance in which Commodore Shufeldt located that number of locks of smaller dimensions.

In any event, Captain Eads has 750 feet in elevation to overcome, and the larger part of this is met upon either side in a rather abrupt rise.

The haul up such inclinations of the vast weights we have been contemplating may well give rise to serious reflections.

On the eastern side of the Isthmus some of the railway grades were 65 feet per mile, with heavy fills, short tunnels, and deep cuts. In the western passes abrupt limestone peaks tower up 1,500 to 2,000 feet, and close along the line are mountain peaks of as much as 3,000 feet elevation.

Large steamers are one-tenth of a mile, more or less, in length, and, in passing from a level to a gradient of 50 feet per mile, one end would be lifted 5 feet before the other would leave the level. As before stated, the load in these changes would fall upon the middle or ends of the car.

The car must be a single, rigid structure, framed to distribute as far as possible the load upon the wheels. In these changes in the inclination of the road-bed, whether graded upon curved lines or otherwise, the middle section will be above the tracks if entering upon an ascending gradient, or the ends will be above them if it be a descending one.

The load carried is a ship, itself heavily laden, the hull of which will resist deflections of every kind.

Should they prove to have the great longitudinal strength Captain Eads accords to ships, either the middle or ends, in passing over changes in gradients, will be off the car, and the vast load would be then *concentrated* upon very few wheels, which would be crushed, and a general wreck would follow. However, we are told, ships are both strong and weak; they at one time bend and twist, (14 and 19,) and at another have enormous strength to resist bending, (20.) But the great load in the ships would, as a matter of fact, force all parts down upon the platform of the car, which in turn would be bent to the tracks.

The entire force of gravity producing these results would act for the moment upon the ends or upon the middle of the car with a destructive effect in proportion to the resistance offered by the ship and car to this bending process. How can springs be adjusted to meet such opposite requirements? For example, to let the central portions down upon their supports when the weight falls there, and retain the ends supported without strains to the vessel; or, when the weight falls upon the ends, to follow up the central portions so as to retain the pressure there, and keep the lines of the ship intact?

If the topography of the country admits of such a method, a ship overlapping 1-10 of a mile, could be brought in a run of one mile, to an inclination corresponding to a gradient of 50 feet, in such manner that the departure of the road-bed from a true plane need not be over 6 inches at any time in that distance; but the effects of the load, while less apparent in so small a deviation, could not be less destructive.

It is only necessary to recall the vast load in the ship operating to crush out what elasticity there might be in the hull, forcing the insufficiently supported sections upon the car with irresistible power.

The effects of the return of the car to a level or to a reverse gradient would be as destructive, if not more so, than the first departure from a true plane. The wedged cargo would not return to its former place without bringing heavy strains upon the ship and car, nor would displaced joints and frames be easily restored.

In such a gradual change as has just been contemplated it would require a run of 2¼ miles to get the ship to an inclination

of 113 feet per mile. Having reached the summit level, 2¼ miles run would again become necessary to restore the ship to the horizontal. The difficulties attending the construction of such a road-bed will be too apparent to need further comment.

Supposing the ship able to withstand these changes without essential injury, how would the car endure it? The resistance of the vessel and the cargo to alternate bending and displacement, the hull going down first in the middle and then at the ends, must at those moments multiply greatly the weight or strain upon the ends or middle of the cars, the real extent of it depending upon the resistance of the hull to this destructive action. The *overhang* would shorten the car, but the leverage of the drooping ends would be a greater evil than the longer car.

The entire elevation to be overcome is 750 feet. In ascending, descending, and undergoing the various changes in inclination involved in the transit, to say nothing of the infinite inequalities in the surface of the road-bed to be encountered, the hull of a ship would be subjected to a series of strains of varied amount and kind, quite sufficient to render it, to say the least, a risky sea venture.

If there are to be but 12 rails, such wheels as can be placed upon them would never take the ship away from the water, and the experiment would end where it began.

Captain Eads has published wood-cuts showing the proposed railway in operation, and locomotives are displayed in the act of hauling vesssls out of the water and up inclines, as is done on marine railways with stationary engines.

Has he considered how far his car must be moved to get a ship out of water? and then how far to attain the level of the river lands? and, finally, how much farther still to bring the vessel's inclination to correspond to that of those lands?

The wheels of the car must go down in at least 35-feet water to get the cradles under the ship. Then on a gradient of 50 feet per mile, it will require a run of 7-10 of a mile to the water level, and of half a mile to the level of the river bottom, and if the deviations from a plane are limited to 6 inches in one ship's length, of about a mile to bring the ship to the grade of the land.

Traction engines are supposed to do the hauling. Has he in-

vestigated the question of power required to haul a ship up that small inclination? By reference to the table of effective powers of locomotives before given [16] it will be seen that it is 244 tons for a grade of 50 feet. If the load were ordinary freight trains over 100 engines would be required.

It is however a very different affair. The massed weight and friction to deal with offer difficulties widely different from those presented by railway trains.

How does he propose to start his load? Traction engines, whatever their power, within practicable limits, can never overcome the inertia of 26,000 tons, represented by a rigid car carrying a single rigid weight of 13,000 tons. Cars in a freight train are started progressively. The locomotive moves forward, bringing its momentum to bear upon the first car, which, starting, imparts a less momentum to the next car in order, and this does the same in lessened degree for the next and so on. Each successive start of the locomotive gives rise to a like series of impulses to the cars until finally the entire train is in motion, and the same thing proceeds until the proposed speed is attained.

Were the train massed in weight upon a single car the locomotive could produce no effect upon it. The difficulty is well illustrated at the Georgetown canal incline, already described. The weight with water in the pontoon is 400 tons, concentrated in a single car, the pontoon. The power is equal to 200 horses. The 400 tons is in effect on a horizontal road-bed, being balanced by equal weights, exerting all their gravity so as to aid in pulling the pontoon. If the car be arrested on the way the machinery cannot overcome the friction of quiescence, and assistance of a powerful character becomes necessary.

Engines that might serve to keep the ship-car in motion, when once started, would be powerless to move it again if arrested. Would stationary engines accomplish it? At Georgetown the steel-wire rope, 2 inches in diameter, was used in such manner that the strain fell upon 6 parts of rope, (2 purchases of 2 single blocks each,) yet it parted. What kind of rope would be necessary when dealing with weights 60 times greater?

[19.]

"It is not generally known that all materials used in the construction of ships are elastic, and that large *iron vessels bend and twist during storms to an extent that seems impossible.* No iron bridges are so constructed but that the elasticity of the iron permits them to bend under the weight of an

> ordinary freight train. Spans of four hundred feet, when tested with heavy loads, usually bend from four to five inches, and a *ship of that length will bend quite as much without injury.* Wood, being more elastic than iron, will bend much more. Those who have crossed the Atlantic have not failed *to hear the creaking of the cabins during storms.* This could not occur if the hull *did not bend and twist to some extent.* The fear of a ship being strained while in transit is founded *in a want of knowledge of the strength of ships* and of the capability of the earth to sustain the load. *Fifteen hundred wheels exerting a pressure of five tons each will create seven thousand five hundred tons pressure.* This weight distributed on twelve rails would require one hundred and twenty-five wheels on each rail. The outer rails would be about forty feet apart, hence the ground covered by the wheels would be equal to a space *three hundred and seventy-five by forty feet, or fifteen hundred* (1,500) *square feet. The pressure, therefore, would be only one-half of a ton to each square foot of earth.*"

It would be a revelation to any of the captains of the transatlantic lines to learn that their ships "bend" and "twist" in a sea-way, as is described above and in [14.] Were there twisting and bending, some evidence would be given at the beams and joints. Passengers might lie in their berths and see cracking of paint in such places.

The comparison of a ship to a bridge is not good. One is to support weights carried over the water, the other to carry weights in the water. One is flexible by construction, the other as rigid as it can be made and have the requisite buoyancy, and is designed to resist outward pressure and longitudinal strains of peculiar character. The working and creaking of "woodwork," on board is one thing; the twisting of the iron hull quite another.

The largest ships carry 6,000 tons weight. How long would a span of the St. Louis bridge support such a weight? Probably as long as would the ship if suspended by the ends or hung in the middle; that is, not for an instant of time, and it would not matter much how few inches the middle or ends of the ship were lifted above the supports.

In this paragraph he describes a ship-car 375 feet long and 40 feet wide, having 1,500 wheels, each bearing 5 tons pressure, or altogether 7,500 tons. In the attempt to avoid one difficulty he has fallen upon another, and overlooked what he had before stated, viz: that the very heaviest steamships weigh 6,000 tons [16;] that his ship-car would be constructed to allow 50 to 60 feet overhang at each end of a ship; that there should be 12 rails under the ship, and that the pressure per wheel should be limited to 5 tons [7.] When it became necessary to deal with a load of 6,000 tons he found the requisite number of wheels

called for a lengthy car, and, to be liberal, ran the weight up to 7,500 tons, requiring a car 375 feet long to take the wheels. But if the pressure per wheel is but 5 tons, the weight of load, and car are included in the 7,500 tons. The vessel, therefore, to be carried, would weigh about 3,750 tons, or nearly the weight of the *Colon* and cargo, and less than that of the *Bucentaur*, 282 feet long by 33 feet beam, because of her deeper load draft, and still less than the *Longhirst*, 285 feet long by 36 feet beam. These vessels are nearly 100 feet shorter than the proposed car, while the car for them, according to Captain Eads' plans, would be each 180 feet long, one being 40 feet wide and the other 33 or 36 feet wide. Only 60 wheels per rail, or 720 in all, can be placed under such a car, and, consequently, the load would be over 10 tons per wheel [16.]

The area covered by the car for the *Longhirst* would be only 6,480 square feet instead of 15,000, as stated by Captain Eads.

A car of 375 feet length, according to the plan, is suitable for the *City of Berlin*, weighing, with load, 11,000 tons. Ship and car would weigh, say, 22,000 tons, and would give between 14 and 15 tons pressure per wheel for 1,500 wheels.

Captain Eads should have had more definite knowledge in preparing plans, and then have been consistent in adhering to them.

[20.]

"The question has been asked, 'How can you equalize this pressure upon the various wheels?' The car which carries the ship will be made of plate-iron cross-girders of sufficient depth and strength, and of such number as are needed to carry the entire load, *even if each girder had no support between the two outside rails of the track; therefore the weight from the keel to each side can be distributed over all the rails of the system.* In distributing the pressure lengthwise it should be borne in mind *that the ship possesses enormous strength to resist bending*, and, beside this, that she cannot *bend in the direction of her length on the car unless the earth gives way under her; hence no longitudinal strength in the car itself is really necessary. The midship section, being much the heaviest*, would produce a greater pressure per foot than an equal length of the ends; but this section is balanced by leaving a certain portion of the ends unsupported. *The car which would carry a ship four hundred and fifty feet long would not be over three hundred and fifty feet; hence, fifty or sixty feet of each end of the ship would project over the ends of the car.* In this way the wheels at the ends of the car would be made to bear as much as those in the middle. In floating-dock, vessels usually have a very considerable portion of their ends without support. Their sides, at the bow and stern, rise directly from the keel, and give great strength to these parts. *An intelligent and reliable correspondent wrote to me recently that he had witnessed the long and tedious launching of the* Great Eastern. '*She was parallel to the river,*

and the ways only occupied one hundred and fifty feet of the middle of the ship, leaving two hundred and sixty-four feet of each end without support."

The weights when loaded of several steamships of 450 feet length have been given in [16,] and is about 10,000 tons. This car, 350 feet long, would be loaded to that extent, the weight of *ship and car* being some 20,000 tons, while the weight per wheel would be over 14 tons.

Any reference to the launching of the *Great Eastern* was most unfortunate for Captain Eads. That experience is full of lessons to which he should give more earnest attention. What had been told him by "intelligent gentlemen" had before led him into erroneous statements, but none in so unkind a manner as in this case.

In "Outlines of Ship-building," &c., by Theodore D. Wilson, N. Y., 1878, and in the *Illustrated London News*, of May 30, June 13, and November 14, 1857, and January (?), 1858, are given particulars of this celebrated launch.

The ship is 680 feet long, and, at the time of launching, weighed 12,000 tons, or less than the weight of the largest loaded steamers previously mentioned, and which Captain Eads must be prepared to transport; but the ship extends over more than twice the superficial area covered by the *City of Rome*.

The distance to the water was 300 feet, the inclination of the ways 1′ in 12′. The ground on which the ship rested while building was piled and otherwise prepared with care to sustain the vast weight. The ship itself is constructed without frames or keel, and after the manner of the Menai Bridge, thus, with the fore and aft bulkheads, giving greater longitudinal strength than is usual.

There were two sets of ways, 120 feet apart, each set 120 feet wide. Consequently 240 *feet of the ship's length*, instead of 150, was sustained in cradles and 360 feet of it included *within them*, leaving 160 *feet of each end* unsupported, instead of 264 feet, "while the hull carried no weight of *any kind* within it."

The ground under the ways was prepared at great expense. Large piles were driven in rows, and oak timbers, 12 inches square, bolted to the pile-heads upon each side, binding the rows together. Over all was laid two feet of hydraulic con-

crete, carefully levelled. This concrete was covered with heavy oak timber. Across this platform transverse oak timbers, carrying the metal rails on which the ship was to move, were laid 3 feet apart and bolted to the timbers beneath. The area on which the ship rested was 20,000 sq. feet. The short incline was made as perfect a plane as could be constructed, and there was nothing but the bare hull to be moved.

Notwithstanding these expensive and painstaking preparations, devised and superintended by the foremost engineer of the time, when the ship was expected to slide gracefully and easily down the ways, it would not start an inch, and no power at hand could move it. This was in November, 1857. In January, 1858, the ship was finally got afloat at an additional cost of $300,000, or $1,000 *per foot* of movement.

The most powerful hydraulic devices were resorted to, and the vessel was forced inch by inch.

It appears that Mr. Brunel considered it necessary to prepare the surface over which the ship was to move on its way to the water, at an expense and labor not practicable in a road-bed 100 to 150 miles in length; yet, with all these precautions, 60 days were expended in forcing the vast hull 300 feet, and at an average cost of $5,000 per day.

It has already been shown that a ship, resting on Capt. Eads' car, weighing 13,000 tons, would cover 23,400 sq. feet of surface.

The launching cradles for the *Great Eastern* did not weigh more than would the cradles and supports on Capt. Eads' car, and not nearly as much as the railway car, with the cradles and supports, for the transportation of such a weight; consequently the pressure *per square foot* was not so great as Capt. Eads must provide for, it matters little what the size of the vessel transported.

What he needs most to consider is the vast power required to move this vessel down an incline so great as 1 in 12, and down which it was expected to move easily by its gravity alone.

The launch of the iron-clad *Independencia* in 1874, (see the periodical "Engineering,") offers another illustration of the difficulties in handling such weights.

This ship is 300 feet long, has 65 feet beam, and draws 25 feet water. Weight ready for sea, 9,000 tons.

At the time of launching the total weight was 6,000 tons. There are two turrets and the armor on the sides is 9 to 12 inches thick. The decks are 2 to 3 inch iron. The turrets at launching were not armored; otherwise the armor was complete. There are two bottoms and the bulkheads usual in such ships, giving a strength no merchant steamship has.

On account of the great weight—only *equal* to the *load carried* by large transatlantic steamers—three sets of ways were laid on each side of the keel, the usual number being one, or at most two sets. The inclination of the ways was $\frac{7}{8}$ of one inch per foot, which is ordinarily sufficient.

On July 16th, 1874, an attempt was made to launch the ship, but without success, as no power at hand could start it. Additional hydraulic appliances were provided, and on the 29th of July it was made to move its length, when the stern had become immersed and lifted by the water. The resistance of the water and the friction there arrested the vessel with about 100 feet of its stern hanging beyond the ways. Three hours after, as the ebb of tide began, the bottom of the ship gave way and its entire extent from the bilges inwards was crushed in; keels, keelsons, pillars, beams, decks, and bulkheads in the engine and boiler rooms were bent, broken or doubled up, and the vessel dropped aft until the stern sunk 8 *feet* in the soft mud and gravelly bottom of the river. Water flowed in and out freely in the tidal movements. Devices were adopted to keep out water, and the ship in time was saved. This vessel *was short* 3,000 *tons* in its load, yet the double bottoms "went in" on an overhang not much greater than Captain Eads proposes for his ship-car—50 to 60 feet—while the great thickness of armor (9 to 12 inches) on the sides, and the heavy iron decks, (2 to 3 inches,) no doubt, together with the support from the river-bottom into which the stern had sunk 8 feet, saved the complete destruction of the hull.

In this Captain Eads may find an instructive lesson as to the power required to move such bodies and the probable effects of overhangs.

One of the river monitors, during the civil war, grounded on a bar in the Mississippi and was left high and dry by the falling river. The vessel had one turret, was all of iron and constructed

with a view to give all possible strength to the hull. The iron bulkheads, longitudinal and transverse, were numerous. The central portion was strongly supported, and situated in that section was the turret and most of the weight. The ends dropped and the vessel broke across by the turret. These facts create some doubts as to the great longitudinal strength of iron vessels claimed by Captain Eads.

[21.]

"It is not important that each wheel should bear exactly as much as its neighbor. Although five tons *would be the maximum average load*, each one would be tested to bear *at least four times as much*, and in practice it might occasionally be required, by inequalities in the road, or even in the distribution of the load, *to bear twice as much*. The *car-wheels on railways are frequently compelled to bear three or four times as much*, while the trains are moving at high speed, as they do when at rest."

It has already been shown [16] that cars constructed as Captain Eads proposes will be subject to loads which will involve 14 tons and upwards as the pressure, when at rest, upon each one of the wheels that can be placed on 12 rails in the length of the car.

If required on account of inequalities in the road-bed to bear *twice* the usual pressure, as Capt. Eads supposes, it would then amount to 28 or 29 *tons per wheel*, or nearly six times the average load he has assumed for each wheel when at rest.

The ordinary freight car wheel bears 2½ tons pressure. There are 4 wheels at each end. The entire weight might fall upon two of them were it not for devices to distribute it over the four, and the two would then support 5 tons each. Were it possible that the whole load should fall upon one wheel, it would still carry but 10 tons.

The effects of concussions are not here considered; but they would be greater proportionately in the rigid ship-car than in the freight-car.

[22.]

"*Let us now compare this pressure of half a ton per square foot, imposed by a large vessel on the road-bed*, with that which we see applied every day to the earth. A man compelled to use crutches carries his whole weight on the ends of them. On a hard dirt road they leave scarcely any sign of the pressure. Assuming his weight to be one hundred and eighty pounds, and the end of each crutch to be equal to two square inches, his weight will be carried upon one-thirty-sixth part of a square foot, which is equivalent to six thousand four hundred and eighty pounds pressure to the square foot, or about six and a half times the pressure that would be

brought to bear by the weight of one of the largest class of steamers. A horse, when trotting, carries the weight of himself and rider on but two of his feet at each step; yet on a dry dirt road his shoes hardly leave their imprint. The area of each shoe will not exceed twelve square inches. If the horse and rider weigh twelve hundred pounds, the pressure would be more than seven times as great as that which the earth would sustain under the ship-railway with its heaviest load. *A brick wall, only one story high, presses the earth more heavily per square foot than the heaviest ship could on the ship-railway.* When ships are launched, the two narrow launching-ways which carry them press the earth with from three to five times as much force per square foot without settling."

The statements here made as to men on crutches, horses' feet, &c., are true to some extent in dry weather, but utterly fail in time of rain, of which there is an abundance at Tehuantepec.

The comparisons are erroneous, because the assumed weight of steamships is incorrect. It would be sufficient answer to point to the care that great engineer, Brunel, thought necessary in the foundations under the *Great Eastern*, and the extent of the ways resorted to in the launch of the *Independencia* [20.]

Capt. Eads' brick wall should be 30 *feet high* to equal the pressure upon his road-bed, and should he attempt to carry a vessel of war [17] he would need to add a number of feet still to the height of the wall.

In launching ships the mere *shell* of the vessel is carried; no machinery, spars, coal, cargo, supplies, or load of any kind add to the weight.

The experience of the Georgetown incline, with its small comparative weight, [15,] must again be referred to in this connection.

The weight to be dealt with can be better appreciated by comparison with the Washington Monument, and a study of the care manifested in the preparation of its foundation will be useful.

Before the recent additions, and when the shaft was 156 feet 4 inches high, its weight was 23,000 *tons*. It is 55 feet square at the base, and then rested on a foundation covering 6,400 square feet and 23⅓ feet deep, of which 7 feet 8 inches was below the natural surface.

The Monument is to be carried up to 550 feet height, when the shaft will weigh 43,500 tons, or probably less than one of those *turn-tables* with its load, which Captain Eads proposes to use in changing the direction of the railroad track. The foundation was regarded as insufficient, and, in fact, the shaft was out

of line from settlements. An addition was made so that the foundation now covers 16,200 square feet area. The new portion was laid $12\frac{1}{3}$ feet deeper than the original one, and was carried under its outer edges 18 feet all around. Thus 14,266 square feet of the strengthened foundation is 35 feet 8 inches deep.

On 16,200 square feet a shaft of 43,500 tons weight will permanently rest. Captain Eads will have a load of some 26,000 tons on 23,400 square feet, and double that amount for *sidings* and *turn-tables*, and it would appear from the foregoing that ordinary road-beds, earth-fillings, &c., would hardly answer to bear the load in safety.

[23.]

"It is a mistake to suppose that ships are not sometimes taken out upon dry-docks with full loads in them. One of the largest German steamers, fully loaded, was taken out within the last twelve months and put upon a dry-dock in New York without the slightest injury, and vessels with their cargoes *are frequently taken out on the docks in England and elsewhere.*"

Reference to the letters of shipbuilders, owners, and underwriters in the appendix will show that loaded vessels are never placed in dry dock, except in an emergency and with great reluctance. It is not correct to state that it is "frequently" done. In fact, the instances are very rare.

Yet, if frequently or infrequently done, it would form no argument in favor of the transportation by rail of loaded ships, the conditions of one in dock and on a car moving 6 to 10 miles per hour, being totally unlike.

[24.]

"The bill before Congress in aid of the ship-railway requires that *a guarantee of six per centum dividends on fifty million dollars, or two-thirds of the capital stock of the company*, shall be made by the United States for fifteen years, the guarantee not to include the principal. It is only to take effect *after the entire practicability* of the plan is proven. Ten miles of road and the necessary terminal works to take a loaded ship out are to be first built, and then tested by transporting the ship and her load over the ten miles of railway at a speed of at *least six miles* per hour, and replacing her in the water again without injury to the ship, the railway, or the terminal works. Even when this is done, the guarantee is only to attach *for five million dollars.* As each additional section is completed and tested in this way, the guarantee for a proportional amount is to attach. As each *ten millions of stock* is guaranteed, *the severity of the test* is increased. For the *first ten millions* the weight of ship and cargo is to be two thousand tons. The next test will be twenty-five hundred; then three thousand; then thirty-five hundred; and finally four thousand tons. In consideration

of this guarantee the company agrees: *First:* to transport, for ninety-nine years, the ships, troops, property, and mails of the United States free. *Second:* to carry no other war-vessels or contraband of war of any nation at war with the United States. *Third:* that *all net receipts in excess of a sum sufficient to pay six per cent. dividends shall be paid to the United States, to refund any advances* they may have made on account of the guarantee. *Fourth:* to give the United States the right to reduce or increase the tolls at her pleasure, provided the reduction shall not prevent the earning *of eight per centum dividends. Fifth:* to give her the right to discriminate in favor of American and Mexican commerce when fixing the tolls."

From what has gone before, it is evident that the trials Captain Eads proposes to entitle him to receive guarantees of $10,-000,000 after each successful experiment would be of no value whatever.

The Government would have secured what?

A road apparently capable of transporting small vessels and not such as are already trading between our Pacific States, China, Japan, Australia, and New Zealand—all of which vessels would find their home port at New York were there a safe Isthmus ship transit.

There is a contradiction in this paragraph as to the guarantee to be received after the first successful trial; but it is assumed to be stated correctly in the last reference, as it accords with the amount to be secured in further trials,

The first one, it is proposed, shall be with a vessel and cargo weighing 2,000 tons. This would be represented by a freight steamer 230 feet long, 30 feet beam, and 16 feet draft,

The ship-car would be 130 feet long, 30 feet wide, and, with 12 rails, would take 516 wheels. Total load 4,000 tons, or 7.8 tons per wheel.

The first trial would therefore fail, because of the excess of pressure over the maximum of 5 tons per wheel. A steamer of these dimensions sometimes draws 18 feet water, or even more. The loaded vessel would then weigh over 2,300 tons, and the pressure upon each wheel would become 9 tons.

The weights of vessel and load at each trial are proposed to be, respectively, as follows:

First trial,	vessel	and	cargo	to weigh	2,000 tons.
Second	"	"	"	"	2,500 "
Third	"	"	"	"	3,000 "
Fourth	"	"	"	"	3,500 "
Fifth	"	"	"	"	4,000 "

The last trial provides for a vessel like the *Longhirst*, 285 feet long, 36 feet 6 inches beam, and 22 feet 6 inches draft, weighing loaded between 4,300 and 4,400 tons; or, the *Colon* in the Panama trade, 280 feet long, 40 feet beam, and 20 feet draft, weighing 3,740 tons. While the lengths are sufficiently similar the narrower vessel, because of its greater depth, weighs 600 tons more than the other.

For these ships the total load, ship-car, cradles, &c., is 8,000 tons, or over 11 tons per wheel. [16.] The last trial, like the first one, would therefore fail from excess of pressure on the wheels.

The Pacific Mail Steamship Company has such ships in service in the Pacific as the *Tokio*, *City of Pekin*, *City of Sydney*, &c. They belong to that class of ships required in the Pacific trade. They are of a size necessary for profitable carriage between our Pacific possessions and Atlantic ports.

The *Tokio* weighs 9,000 tons. The weight of ship and car, &c., would be, say 18,000 tons, [16,] and the load upon the road would be 10,000 tons greater than the highest test proposed for the ship-railway

The width and length of car employed in the fifth trial would be wholly inadequate and useless for such transportation.

The *Tokio* has 48 feet beam and its weight gives over 14 tons pressure per wheel, [16.]

The width covered by the rails in the fifth trial is not sufficient for this larger ship, while the road-bed that endured the former load would not support the latter. An entire new structure would be required.

In a previous paragraph, [21,] Captain Eads admitted the wheels might, when in motion, be subjected to double the pressure upon them when at rest. In the carriage of the *Tokio* this would involve 28 tons, nearly six times the maximum pressure he proposes for them when not in motion.

The ships trading with the west coast of South America are also of great size and carrying capacity. These, too, as well as most of the steamers of the West India lines, reaching Panama, would be shut out from the proposed railway.

In short, the trials would be of no value to the larger interests to be subserved by an Isthmus ship transit route.

To be effective they must from the first be made with vessels of the very largest class.

Then that part of the road, completed and found successful, which the Government might pay for, would serve the interests intended to be advanced.

When the large ship had been carried successfully over, the lesser ones probably could be provided for in some manner.

Increased expense, in comparison with the ordinary railway expenditures, would arise from the necessity of having numerous cars to suit the vessel to be carried, or the large car, weighing much more than the ship ordinarily transported, would be drawn back and forth over the Isthmus heights at heavy cost. The railway freight train is made up of small cars, which can be attached to or taken from a train according to circumstances. The ship train would be made up of one car and one ship. Cars cannot be made in sections, because inequalities would bring crushing pressure upon the wheels at the ends of the sections, where no distribution of weight could be effected.

The cradles, supports for ships, sides, &c., would need to be as varied, almost, as the vessels carried.

Captain Eads states the advantages the United States are to reap from their guarantee.

Referring to them, in the order they are given, they compare with those contained in the Nicaragua Canal concession, as follows:

"*First.*" The treaty with Nicaragua provides for the same advantages, without cost to the United States, for any ship transit across the territory of that republic.

"*Second.*" This is a condition the United States must enforce by superior force, and may do it as well elsewhere as at Tehuantepec. The promise of the railway company would be of no value whatever when called upon by any enemy to perform the service.

"*Third.*" We all know that if any capitalists believed the road would earn over 6 per cent. on its cost, (no one can yet say what the cost would be,) they would be entirely ready to advance the money without guarantees from the United States.

"*Fourth.*" The United States has already exercised by treaty stipulations this right in the treaty with Nicaragua in respect to any interoceanic transit across that Republic.

"*Fifth.*" How long would the United States allow a discrim-

ination against its commerce over Captain Eads' road, should he fail to get assistance from them and obtain it in England, for example, as he threatens to do later on?

A discrimination is not practicable either in Mexico or in Nicaragua.

[25.]

"To avoid any question as to what are net receipts, the company agrees that *one-half of the gross receipts* shall be deemed sufficient *to pay operating and extraordinary expenses, repairs*, &c., so that when the total receipts are *six million dollars* per annum, the United States will incur no liability under its guarantee."

Captain Eads here puts the annual expense of his railway at $3,000,000 when receipts are $6,000,000, or 50 per cent. of earnings. Will the expense be $2,000,000 when receipts are $4,000,000? The cost of maintenance and management would be very nearly the same for the smaller as for the larger earnings.

The railways of this country do not succeed in keeping their expenses so low as 50 per cent. of receipts. Sixty and sixty-five per cent. are common figures, and there is no reason to think the ship-railway can be as economically worked as an ordinary one.

The Government of the United States is to make good 6 per cent. on $50,000,000 until all expenses are earned, together with 6 per cent. upon capital shares. What is the limit of bonds? What of the stock on which this 6 per cent. must be paid before the United States are to be refunded any of their advances on account of these guarantees?

[26.]

"The grant from Mexico gives to the company the *right to offer these advantages to any other foreign government* that will aid the enterprise with money or guarantees."

It appears from the above that the company proposes to apply to different governments for assistance, in the same manner it is now doing with the United States, granting to each one giving "aid" those advantages enumerated in a previous paragraph. It is not clear from this what *special advantages* the United States are finally to enjoy in consideration of the payment of $3,000,000 yearly.

If this is not the meaning of the paragraph, then it is a threat that if the United States do not furnish the funds application will be made elsewhere and exclusive privileges offered.

Attention is invited to this paragraph in connection with the last one of Captain Eads' article, in which Mexico is represented as appealing with open arms and special sisterly love to the United States to aid in her efforts to draw more closely the bonds of friendship and sympathy by means of a system of internal improvements that shall unite with our own and be, in effect, an extension of them.

[27.]

"The popular feeling in the United States has unquestionably, until quite recently, been favorable to Nicaragua, and many arguments have been advanced in its behalf. Every one of these is doubly powerful when applied to the Isthmus of Tehuantepec. The whole question between these two locations must depend on the answer to this inquiry, namely: 'Is the ship-railway practicable?' *No engineer, so far as I know,* has yet publicly expressed any doubt of it. On the contrary, *some of the ablest engineers and ship-builders in the world* have expressed implicit confidence in its practicability."

In the discussion of paragraph [7] it was shown that the interests of commerce would not be subserved by constructing a transit for shipping so far north as the Isthmus of Tehuantepec.

There is consequently something else to consider than the mere practicability of a ship-railway. That question is sufficiently grave, it is true, but it is not the only one to be solved.

Again, it is pertinent to ask why Captain Eads does not publish the letters of the very prominent engineers and ship-builders who laud his proposed undertaking. In the appendix will be found letters of many who take quite a different view.

[28.]

"If we consider the healthfulness of the two isthmuses, there can be no question as to the superiority of Tehuantepec. If we look at the shortness of the routes, Tehuantepec still has the advantage. When we compare the canal and its numerous locks and the delays incident to their use, to say nothing of the danger of their derangement, with the certainty and celerity of transit by railway, the superiority of Tehuantepec is no less marked. It is claimed that the Nicaragua Canal will complete our coast line between the Atlantic and Pacific, but how much more secure and complete will it become if we exclude from it a foreign coast line on the Isthmus as long as that which extends *from the capes of Florida to Newfoundland!* This will be done by the ship-railway at Tehuantepec."

This statement as to relative healthfulness of Tehuantepec and Nicaragua is purely imaginary.

The writer has been exposed in both localities and has had malarial fevers in both.

Captain Eads refers to the comparative safety and security of the railway in all aspects.

Compare his 29 miles of canal and 2 *locks* with the 53.17 miles *via* Nicaragua; his 35 miles of river navigation to be deepened, straightened, and otherwise improved with 63 miles of the San Juan, held by a single dam at level with the lake, the current not exceeding half a mile per hour; and, finally, his 110 *miles of ship-railway* with the 57 *miles navigation across Lake Nicaragua.*

Newfoundland is a broad country, but 1,835 miles is the distance from the capes of Florida to Cape Race.

In comments to paragraph [11] the difference in distance between New York and San Francisco *via* Tehuantepec and *via* Nicaragua is given as 560 miles in favor of the former.

Then, distance capes of Florida to Newfoundland..................	1,835 miles.
Difference in distance New York to San Francisco in favor of Tehuantepec	560 "
Error in Captain Eads' statement..................................	1,275 miles.

[29.]

"Much has been said and written of the importance of cultivating more intimate commercial relations with Mexico, and no thoughtful merchant or statesman can fail to concede it. In the first place, she has a Government fashioned after the plan of our own, and we should on this account, if on no other, be bound to her by the strongest sympathy. Her soil is wondrously fertile and productive. Hidden in her mountains, within the easy reach of enterprise, *lie stores of gold and silver in fabulous amount.* Many articles of commerce which we require, but cannot produce, are brought to great perfection there, and her people require innumerable manufactured articles, commodities, and productions which we could supply to them, with great profit to us and advantage to them. There is, indeed, no good reason why we should not enjoy almost all of her commerce.

"There can be no doubt that the construction of the ship-railway at Tehuantepec will greatly stimulate intercourse between us, and it must *bind the two nations more firmly together*, socially, politically, and commercially."

These two paragraphs read very well as an effort of imagination, but will not bear light.

Tehuantepec is in a remote part of Mexico, isolated from its populous and productive sections. In what particular way can a ship-railway across it promote commerce between the two countries? Whatever of trade the west coast of Mexico now enjoys or may come to enjoy, with our Atlantic ports, would just as readily pass by the Nicaragua route. Tehuantepec, in itself, is not and cannot become a very valuable commercial section of Mexico.

As for the "fabulous stores of gold and silver," it may be safely asserted no portion of southern Mexico ever had an approach to reputation for mineral wealth enjoyed by the province of Chontales, on the east side of lake Nicaragua.

The effect of the ship-railway as a bond of union is not clear to ordinary apprehension. Such an argument would better apply to Central America; thus, our railway system is being extended into Mexico and will serve to bind the two Republics by ties of common interests; having in this way secured that advantage let us now build a ship-canal across Nicaragua which shall serve, also, as a bond between the little Republics of Central America and ourselves, thus extending our influence and close business alliances to the shores of South America.

[30.]

"I will not, at this time, dwell upon this important topic, but will simply refer to the following table, taken from official records, showing the commerce with the various nations therein specified :

British India	$423,000,000
Australia	375,819,000
China	198,000,000
Hong Kong	112,000,000
Peru	75,000,000
New Zealand	71,782,000
Chili	58,000,000
Japan	55,230,000
Philippine Islands	34,763,000
Tasmania	14,835,000
Hawaiian Islands	7,524,000
	$1,425,953,000

"Of this vast commerce the United States enjoys but four per cent., and even in this trifling percentage the Mississippi Valley is debarred by the Isthmus from all participation."

The table inserted here is a mystery. "*Table taken from offi-*

cial records, showing the commerce with the various nations therein specified." What does it mean? What is the table there for? Presented without explanation, its application to the ship-railway scheme is not readily discovered.

[31.]

"Our sister Republic of Mexico has *been most liberal* in concessions in aid of the ship-railway. Realizing the great benefits that will inevitably follow its completion, she has given everything in her power to make it a success. *First.* She exempts all property of the company and its capital stock from taxation during the entire period of ninety-nine years. *Second.* She permits the importation, during the like period, of everything necessary for the construction and operation of the railway. *Third.* She gives a right of way across the Isthmus a half mile in width. *Fourth.* She donates to the company a million acres of the public domain. *Fifth.* She exempts all the money required to pay debts and dividends of the company abroad from the present export duty of six per centum; and *Sixth.* She agrees to protect the works with her army and navy, at her own expense. But this is not all. Anxious to cultivate *more intimate relations with us*, Mexico offers to the United States Government rights and privileges greater than any ever before extended by her to either government or individual. She says to the United States: You may regulate, at your will, the tolls of this company. You may reserve the right to discriminate in favor of your own commerce. You may accept an *assignment of the revenues of the road*, and our courts will protect you in its enjoyment. Come, *join us in consummating* the most important work of modern times —a work which, completed, will bring manifold blessings to you and to us. What answer will the United States give to this urgent invitation? It comes from a nation which, but recently emerging from the throes of foreign invasion and domestic revolution, has, through the wisdom of her rulers, established herself upon a firm basis, and promises in time to rank high among the nations. Just now her treasury is depleted, and the masses of her people are poor, although there is probably no equal area of territory on earth so rich in undeveloped wealth. But her present poverty has not prevented the exercise of a statesmanlike liberality in dealing with this great question. Her invitation is made to the foremost nation on the earth; one whose credit is second to none, and whose wealth and resources are illimitable. She offers an opportunity to solve the great problem of centuries, and to assist the Monroe, or rather American, doctrine, not by idle declaration, nor by force of arms, but in a way to command the respect of the world. The United States to-day enjoys but five per cent. of her entire foreign trade: ninety-five per cent. of that valuable and growing commerce is controlled by foreign nations. Will the United States reverse these figures? or, will she disregard the overtures of Mexico, decline her liberality and reject her commerce by refusing to join with her in opening, for mutual benefit, the grandest commercial highway ever projected?"

The liberality of Mexico! Contrast its ship-railway grant with the Nicaragua Canal concession in the order as above given.

First. Precisely what Nicaragua grants.

Second. Same as Nicaragua grants.

Third. Besides granting the same, Nicaragua makes a *free zone* along the entire route.

Fourth. Nicaragua's land grant is still greater in amount and more valuable.

Fifth. Nicaragua is a free-trader in money, and exacts no export dues.

Sixth. Nicaragua does the same, and is able, at least, to protect the work from her own citizens.

In addition, Nicaragua does not require that the company shall be Nicaraguan, nor that the stockholders shall be held to be Nicaraguans; does not prohibit the United States becoming partners or stockholders in the canal company, and pretends to no control of the canal.

What are the great privileges granted by Mexico, and so much applauded in this article? "The concession declares that the ship-railway company shall be Mexican; that its shareholders shall be considered as Mexicans; that the company shall claim no exemption from the operation of Mexican laws and the control of the Government of Mexico on the plea of being a foreign corporation."

It declares that the contract (Art. 25) shall be void "for alienating, transferring, or mortgaging this concession or the rights derived from it to any foreign state or government, or for admitting it as a partner and any stipulation to this effect being also null." The liberality seems to consist in scattering citizenships about with a free hand.

The United States are asked to pay $3,000,000 yearly for 15 years, or $45,000,000 in all, without added interest, taking for security an assignment of *net earnings*, an obligation that cannot be secured in any way upon the property. The personal liability of Captain Eads and his associates is all the Government would have to rely upon.

No assignment, transfer, alienation, or mortgage to a foreign government can be made, and no partnership entered into; and if such be done the government of Mexico at once enters into possession of the road. There is evidently considerable apprehension on the part of Mexico instead of an invitation made with open arms to join with her in this work.

In the foregoing comments repetitions have been general, because the purpose has been to meet statements made by Captain Eads, as they occurred in the successive paragraphs.

The errors and miscalculations found in all parts of his paper will have attracted attention.

It would seem characteristic of Captain Eads to deal in uncertain numbers. The following references to the history of the St. Louis Bridge and its approaches are made in order to illustrate this trait.

The original estimate, presented by him, was as follows:

I.	Superstructure of bridge	$1,460,418 30
II.	Substructure	1,540,080 00
III.	Approaches	520,397 24
IV.	Tunnel	410,477 55
V.	Land and land condemnations	539,900 00
VI.	Railroad	25,680 00
	Total	$4,496,953 09

See report of the Engineer-in-Chief of the Illinois and St. Louis Bridge Company, St. Louis, May, 1868, signed James B. Eads.

A report was made to the company by a committee of stockholders, appointed for the purpose of inquiry into its financial condition, February 3, 1875.

From this report it is learned that the actual outlay up to October 1, 1874, had been:

For the bridge	$13,313,880 13
For the tunnel	1,898,718 33
Total	$15,212,598 44

The property has been since sold for less than the original estimated cost.

Various obstacles and dangers to be encountered in a ship-railway are not mentioned in the review article.

For example, great difficulties would arise in the *turn-outs* for meeting ships.

Captain Eads, elsewhere, proposes to use *track-cars* or shifting tables on which one of the meeting trains would be drawn to one side, and another track run into the opening thus made for use of the passing train. These movable tracks, or sidings, would be wonderful affairs, carrying, besides their own necessarily enormous weight, 26,000 *tons!* Immensely powerful stationary machinery would be required to haul them to one side, and the cost and expense of the whole would be prodigious.

A source of serious danger would arise in gales of wind at certain seasons, of very frequent occurrence at Tehuantepec. They are violent and sometimes of long duration. In Commodore Shufeldt's report mention is made of one lasting 14 days.

A ship's hull 550 feet long, and, including car, 60 feet high, the masts, yards, smoke-stacks, and top-hamper, being yet much higher, would present a great surface to winds. It is usual to compute such effects by assuming the wind pressure to be 55 pounds per square foot on a plane surface, equal to *half the pressure of a loaded freight car upon a track.* The leverage would be great and it will be seen that the increased pressure upon the lee wheels from that source would become a very grave matter.

From what was shown in [16] and elsewhere it is manifest that the 12 rails proposed by Captain Eads will not suffice for the weights to be carried. Indeed, the loaded ships alone would give more than 5 tons pressure to each wheel on 12 rails, [16.] But the width of tracks also offer difficulties not yet considered, as follows:

The steamship	Longhirst	is 285 feet long and	36 feet wide.		
"	Tokio	" 423	"	48	"
"	City of Rome	546	"	52¼	"

In order to be well within the probable weights, let us suppose the cars, cradles, and fixtures for each of these ships to weigh in the same proportion to weight of the vessel and cargo that the platform car does to its load, or say two-thirds, then the weight of ships and car would be.

Longhirst and car,	4,300 + 2,866 tons,	= 7,166 tons;	wheels required,	1,433
Tokio "	9,000 + 6,000 "	= 15,000 "	"	3,000
City of Rome "	13,000 + 8,666 "	= 21,666 "	"	4,333

The car for the first-named vessel would require	23 rails.
" " second " "	28 "
" " third " "	29 "

Thus it appears the smaller ships would require more rails in proportion to width than the larger ones.

The marine railway at the Washington Navy Yard furnishes an example of the difficulties arising from friction in moving great weights upon wheels. While the power and ways in use,

theoretically, are sufficient to haul out vessels of 2,000 tons weight, it is found that those of 1,000 tons are a safe limit to undertake.

Friction and inertia, among the greatest difficulties to be overcome in a ship-railway, are not referred to in any of Captain Eads' publications, while the weight to be drawn is so great that no experience has furnished data for determination of what the resistance from these sources would be. In this connection attention is invited to the letter marked "E" in the appendix, written by a well-known and very able engineer.

Within what may be considered as the practical limit of expenditure for a Isthmian ship-transit line these obstacles may be deemed insuperable. They have heretofore baffled the highest engineering skill when dealing with weights but a fractional part of what Captain Eads proposes to transport.

In comparing the relative merits of a canal and ship-railway many things are to be considered upon which Captain Eads has never touched, or, if referred to all, it has been by assertions unsupported by references, facts, reasoning, or fignres. For the better understanding of the subject it is necessary to present the more prominent points.

The one to which the investor would naturally turn attention with the greatest degree of interest is that of relative cost, and we are at once met with the absence of surveys for the ship-railway.

The estimates for the Nicaragua ship-canal are based upon carefully conducted surveys and locations. The measurements and character of excavations are determined, the rates adopted known, and the exact work proposed to be done is delineated and published with details, so that the expert may judge of their reliability.

For the railway no surveys exist, and no surveys of the Isthmus of Tehuantepec are available except those made for other purposes.

Captain Eads announces indefinitely that there will be from 100 to 110 miles of railway; that the Coatzacoalcos river and tributary will be utilized for navigation to a certain point, and that lagoons on the western side will be canalized and artificial harbors made on either side.

General Barnard in his report states the air-line distance across to be 143.5 miles. His railway line, with twenty miles of river navigation, was 186 miles long, while the surveyed line for a ship-canal was 179 miles.

From these surveys it appears there would be:

Of ship-railway	110 miles.
Of canal	29 "
Of river navigation	35 "
Total	174 miles.

Fifteen miles of the canal would be in a lagoon having 2 to 6 feet water.

The general depth of the crooked river is 20 feet; hence the channel must be both deepened and straightened.

The ascent to be made cannot be materially reduced from 750 feet, that being the elevation generally of the highlands, for some 19 miles. Situated in this are peaks of 3,000 feet in altitude and along the west margin are limestone cones of 1,500 to 2,000 feet elevation.

The cost of grading for a ship-railway in that region, having in view the difficulty attending changes in its directions or in inclination, would probably be quite as expensive as the complete excavation for a ship-canal along the same line. (See letter of A. Savery, civil engineer, in Appendix.) The cost of the superstructure of such a railway would be very great, consisting as it would of 28 to 36 lines of rails, being equal to 1,540 to 1,770 miles of single railway tracks laid upon stone foundation and very heavily timbered. There are also about 29 miles of canal, 2 locks, 35 miles of expensive river work, 2 difficult harbors to make, and those enormous *turn-tables*, *siding-cars*, equipments, &c.

Viewed in this way the cost becomes alarming in its prospective summing up.

An approximate estimate for cost of railway, much more reliable than anything heretofore furnished the public, can be made by assuming the rates used in the Nicaragua canal estimates.

For example, by taking the cost of Captain Eads' canal per mile to equal the least costly Greytown end of the other; the average of all canal excavation across Nicaragua as the average for grading, filling, and preparing road-bed for 110 miles rail-

way, including masonry for each rail, &c., the two harbors at the cost of those at Greytown and Brito, and the locks the same for both canals.

The results of such calculations are as follows:

29 miles of canal at $333,333 per mile	$9,666,657
2 locks at $400,000 each	800,000
110 miles grading and preparing road-bed, including masonry, &c., at $400,000 per mile	44,000,000
2 harbors, same as estimates for Brito and Greytown	5,160,369
Deepening and straightening the river, same amount as estimated for San Juan river	2,066,170
	$61,693,196
Add 25 per cent. for engineering contingencies	15,423,299
	$77,116,495
Add for superstructure and equipments, including steel rails, much heavier than for ordinary railways, *siding-cars, and turn-tables*, with powerful *engines for each one*, cradles, tracks laid on heavy timbers resting upon stoneways, locomotives, ship-cars, &c., at $40,000 per mile of single track, of which there would be the equivalent of at least 1,540 miles	61,600,000
Total of above items	$138,716,495

This amount would be liable to large increase for *additional lines of rails;* and there is still to be added commissions, interest during time of construction, land condemnations, &c.

The estimates covering corresponding items for the Nicaragua canal are:

53.17 miles of canal complete at $509,995.61 per mile, and 13 locks at $400,000 each	$32,314,340
River, lake, and harbor improvements	8,879,499
	$41,193,839
Add 25 per cent. for contingencies	10,298,460
Total cost for engineering items	$51,492,299
To this amount must be added, as in the case of the railway, commissions, interests, &c., which are estimated to swell the total cost to	$75,000,000

It is thus plain that the railway would cost at least twice as much as the canal, as, indeed, it should, since the canal would be only 53.17 miles long, the remaining distance across Nicaragua being made ready to hand by nature. The cost of a single dam and the expenditure of $3,719,130 in cutting away four

shoal places is all there is to do in making 120 of the 173.5 miles across Nicaragua navigable for the largest steamers when propelled by their own power and at high speed. In the river above the dam there would not be exceeding half a mile current per hour, and that is about the rate now in the part extending for 30 miles from the lake. Sailing vessels could be towed in it and the lake with great facility and speed.

Captain Eads would have more than half as much canal to construct, as much river expenditure to make, and more difficult harbors to prepare before striking a blow upon the line of the 110 miles of ship-railway. It is therefore self-evident that the railway must be much the most expensive work to construct.

To contrast the effects of railway and canal upon the carrying trade, it will do to assume an equal cost for that purpose, remembering that, were the greater cost of the railway taken into account, the result would be much more favorable to the canal.

Let us assume the cost of each to be $75,000,000. Captain Eads proposes that 6 per cent. shall be earned and paid upon the capital shares of the railway company before the United States shall be entitled to repayment of any advances made on account of its guarantee before referred to, [24,] and he states that the expenses of the railway will be 50 per cent. of the gross earnings [25.]

6 per cent. on $75,000,000 per annum is...	$4,500,000
50 per cent. of gross earnings is...	4,500,000
Total earnings necessary to pay 6 per cent. on cost......	$9,000,000

That is at the rate of $3 per ton for the business he expects to enjoy [7.] The expenses, as in case of all railways, would probably exceed 50 per cent. of receipts.

For the expenses of the canal we have more definite knowledge from the experience at Suez and elsewhere. That canal is 100.15 miles long and is subject to sand drift, making the expense for dredging a heavy one both in the canal and in Port Said harbor.

Vessels are towed in the canal at 2½ miles per hour average for the entire distance, the strong winds across its line operating to impede their progress.

In Nicaragua there would be no sand drift and no silt, the water used everywhere being clear and pure from the lake; no

dredging, no destructive lines of drainage to make large expenditures necessary, and no strong winds to impede vessels in the canal. Steamers would be towed only in the canal proper, while sailing vessels, as before stated, could be towed at high speed in the river and lake. On the other hand, there would be 13 locks to pass. Thus most of the expenses would be ratably smaller than at Suez.

The Louisville Canal is 2 1/7 miles long, has 2 locks respectively of 12 feet and 14 feet lift. The yearly dredging averages 60,-000 *cubic yards*, while the average expense of all kinds is $40,000 *annually*. Three thousand one hundred and sixty-eight vessels passed it in 1880. (See annual reports of the Chief of Engineers.)

The Des Moines Canal is 7.6 miles long, has 3 locks large enough for largest river steamers. The dredging is a heavy charge, but the total yearly expense is, except in extraordinary emergencies, $30,000. (See annual reports Chief of Engineers.)

The St. Mary's Falls Canal is 5,400 feet long and the lock is the largest in dimensions and lift in the world; yearly expense estimated $25,000.

The expenses of the Suez company of every kind is 4,389,000 francs per year, (see reports of the company, fall of 1880,) or say $833,910, equal to $8,326 per mile.

The *pro rata* amount for Nicaragua would be $445,441 yearly. Add $10,000 for each of the 13 locks to cover any doubts as to comparative costs of working the two canals, making $575,441, or say, in round numbers, $600,000, which is equivalent to $1,130,000 for the Suez Canal.

$75,000,000 at 6 per cent., as before, is yearly	$4,500,000
Expenses yearly of canal company	600,000
Total	$5,100,000
Total for Tehuantepec	9,000,000
Differences in favor of Nicaragua Canal	$3,900,000

Captain Eads estimates the tonnage to be carried at 3,000,000 tons, on which amount the charge per railway would be $3 per ton and *via* the canal $1.72, a difference in favor of the canal of $1.30 per ton, which is 3 3/5 cents per bushel for wheat.

Special rates of high order for insurance against the railway would also favor the canal as respects charges.

But the road would in fact cost much more than the canal,

and should it cost twice as much, as no doubt it would, the charges by canal would become $2.80 less per ton than by the railway, a difference equivalent to 8 cents per bushel for wheat.

Suppose a steamer to carry 1,000 tons cargo between San Francisco and New York at $10.50 per ton, which is at the rate of 30 cents per bushel for wheat: Time *via* ship-railway 19 days; *via* ship-canal 21 days [9.]

The railway dues would be $3,000 and the canal dues $1,720. The freight earned, less transit charges per railway, would be $7,500, and per canal $8,780, or $394.74 per diem for the former and $418.10 for the latter. The ship, therefore, would be best paid by taking the canal.

In voyages to our Pacific ports from our Atlantic ports the difference would be more favorable to the canal than is above assumed, and from European ports the time of voyages would be about the same by either route, the distance being in the former case 560 miles less *via* Tehuantepec, [9,] and in the latter hardly anything, as will be seen in the accompanying chart, taken from Bowditch's Navigator, and therefore correct. Opposing currents and less favorable winds would offset most of the advantage Tehuantepec possesses in distance.

For sailing vessels the voyages would be more favorable *via* the canal, [9,] so that the difference in tolls would be all saved.

The reduction in transit charges would of course cheapen freights, a matter of prime consequençe to the agricultural interests of the Pacific States, and it should not be forgotten that a large majority of the carrying trade [7] between the Atlantic and Pacific oceans would be taking the longer distance in going *via* Tehuantepec, thus encountering double disadvantage by increase in distance and by larger charges.

The promoters of the Nicaragua Ship-Canal published a report, October 15, 1880, setting forth estimates of the probable business of a ship-canal across that country, based upon Mr. Nimmo's tables, corrected for the present grain trade of the Pacific Slope, and also for certain considerations affecting the carrying business with the Pacific ports, in respect to which Mr. Nimmo was not informed.

Referring to Table I, [7,] the several items were amended for reasons set forth in the report, as follows:

Item 1.	Tonnage entering at Panama ports....................	746,200 tons.
" 2.	Tonnage between our Atlantic and Pacific ports...	250,000 "
" 3.	Tonnage between our Atlantic ports and foreign ports west of Cape Horn..............................	230,447 "
" 4.	Tonnage between our Pacific ports and foreign ports east of Cape Horn............................	1,500,000 "
" 5.	Tonnage between ports of Europe and Pacific ports west of Cape Horn not in the United States...	957,448 "
" 6.	Tonnage between British Columbia and European ports.....	22,331 "
	Total estimated existing tonnage offering for a canal..	3,706,426 tons.

On this basis it was considered safe to adopt 3,000,000 tons as the business now offering for the Nicaragua Canal.

In view of what has been shown in regard to length of voyages by the respective routes, the tonnage in the foregoing table, distributed according to the geographical position of the ports between which the carriage was conducted, exactly as was done with Mr. Nimmo's Table I, in [7,] would indicate the following results:

	Tonnage for which Tehuantepec is the shorter distance.	*Tonnage for which Nicaragua is the shorter distance.*	*Tonnage that might take either route, as respects the voyages.*
Item 1......... ...	43,028 tons.	703,172 tons.	——
" 2............	250,000 "	——	——
" 3............	——	101,239 "	129,208 tons.
" 4............	——	18,568 "	1,481,432 "
" 5............	11,438 "	946,010 "	——
" 6............	——	——	22,331 "
Totals.....	304,446 tons.	1,768,989 tons.	1,632,971 tons.

Thus Tehuantepec is less distant for 304,466 tons; Nicaragua for 1,768,989 tons, while 1,632,971 tons, *other things being equal*, would take either route with like advantage. Total of all, 3,706,426 tons.

From this it is clear that the Tehuantepec route, geographically, would be a disadvantage to a large portion of the carrying trade between the two oceans, and that the higher charges for the railway would be an unnecessary and oppressive tax upon ship owners or upon shippers, but which, finally, would fall upon producers.

Our ports in the Gulf of Mexico, in their trade with the northwest Pacific coast ports, would enjoy some advantages, and

possibly, sufficient to counterbalance the two or three dollars per ton higher, charges to which their business would be subjected; but all their trade with Central and South America would pass equally well *via* Nicaragua, while it *would suffer from the high railway charges if passing by the other route.*

The largest interest to benefit by an Isthmus ship transit is that engaged in grain cultivation on the Pacific Slope.

The market for the crop is mostly in Europe, and the transportation thither would be quite as advantageous in respect of the voyages by the canal route as by the ship-railway, while the saving in charges by the former would become an item of importance. A difference in freight-money for the exportations from that section during the current year of 3⅔ cents per bushel of wheat would have amounted to $1,500,000. A reduction of 8 cents per bushel would have put $3,360,000 in the pockets of the Pacific Slope wheat-growers of 1880, and, as before stated, the canal charges could probably be that much less than those of a ship-railway, while giving the same returns to shareholders.

The final summing up is about as follows: Water transportation for ships by way of Nicaragua can be created without engineering difficulties and at moderate cost, so as to secure reasonable tolls. The vessels passing there, being retained in their natural element, would not be subjected to trials and contingencies for which they are not designed, while the geographical position of the route favors a larger proportion of the carrying trade than any other one proposed.

Captain Eads purposes to take vessels out of water, in which they are easily and safely moved, for transportation by land, where the difficulties to be overcome, if not insuperable, are certainly very great, and where the power required to move them would be enormously larger and their exposure assuredly great.

Not a compensating advantage would be gained of any kind whatever—not even for the ports of Louisiana and Texas, which would lose in their carrying trade as much by increase in charges as they would gain in time.

Captain Eads might profitably regard two patient mules above Georgetown, pulling a loaded boat along the placid bosom of

the canal at the rate of three miles per hour, and then observe the efforts of an engine representing the power of 200 horses in transferring the same boat over the incline, on which the load is balanced by equal counterweights.

WASHINGTON, *June* 13, 1881.

After the foregoing review had gone to press I received a copy of the letter (see last one in the Appendix) written by William J. McAlpine, Esq.

In an interview with him since its receipt I learned that he had just returned from Tehuantepec, and had, before leaving there, passed over the line now proposed by Captain Eads' engineers for the ship-railway. It appears that it is the present intention to have a uniform gradient to the summit level, there 800 feet in elevation, a plan involving an immense amount of excavation, and a cut not less than 800 feet deep at one point.

The estimates found on page 59 should be largely increased for the items there set down for fillings, excavations, masonry, and preparation of road-bed, in order to provide for the larger amount of such work involved should this plan be finally adopted.

S. L. PHELPS.

APPENDIX.

OPINIONS OF SHIP-BUILDERS.

"I am in receipt of your communication, and in reply I have to say that in my opinion a ship or steamer of large dimensions cannot in safety be taken out of the water with cargo on board, as there would be great danger of injury to the hull, and consequently cannot be safely transported with cargo on a ship railway.

"Very respectfully,

"JOHN ROACH."

Wm. H. Webb, Esq., the celebrated ship-builder, concurs in this opinion.

The Harlan & Hollinsworth Company, of Wilmington, Delaware, say: "If the foundations of the railroad, having six tracks, could be made *substantial, so as not to yield* under the immense weight of a loaded ship, we believe that a cradle could be constructed to receive the ship and transport it the distance named without injury. But to do so the ship would have to be constructed specially for such service, having such peculiarity of construction as would permit such handling without fear of injury. The ordinary wooden vessel of to-day would hardly venture upon such a journey overland; neither would underwriters take the risk of damage unless vessels were prepared for such service.

* * * * * * * *

"We have read very carefully the letters written by Admiral Ammen to Mr. King. We think he has left very little to be said hereafter, as he has covered the ground fully."

The Pusey & Jones Company, of Wilmington, Delaware, say: "So far as relates to injury resulting to the vessel itself from being raised from the water while loaded, opinions will differ. A new, strongly-built *iron* ship might endure this without damage, but in our opinion the element of danger of sustaining serious damage while being transported under such condition would be regarded by the average ship's owner as a risk which he would not be warranted in taking, and we are further of opinion that underwriters would share the ship-owner's views.

"In so far as the element of danger of sustaining damage relates to wooden ships, or iron ones whose plates have become thinned by age, the carriage proposed would be simply destruction.

"However well a ship might stand the strain of being quietly docked with a heavy cargo on board, the fact could hardly be used as an argument that she could be safely transported while so raised from the water; the dynamic effect of the load and of the boilers and machinery would be an element of danger that only extraordinarily strongly built ships could resist, and very probably even these would not.

"As to the uniform solidity of the road-bed necessary to safety of transportation, we are of opinion that in a country so subject to heavy falls of rain as is that of the one on which it is proposed to make the road, the problem presented is so difficult as to be scarcely capable of solution.

"Finally, we think the whole question of a ship-railway, as proposed, is so full of grave and scarcely surmountable difficulties that it is scarcely worth consideration."

T. F. Rowland, Esq., Continental Works, N. Y., says: "I have some crude notions as to the best method of moving large and heavy bodies, and feel certain that 'carriage on wheels' cannot be so classified. Although it may be theoretically possible to equally distribute the weight of a moving body upon any desired number of supports, practically it is almost a mechanical impossibility to do so. A four-wheeled vehicle will equally load each, but if another pair of wheels are added they will carry the whole load or no part of it, as the road varies more or less from a perfect plane. In cars and locomotives eight wheels in place of four are desirable, but experience has proved they must be grouped in trucks or harnessed with springs, equalizing bars, or other devices in order that in effect the load must rest upon *four* points only. The car and locomotive are strong enough for this treatment, but not so the ship, whose shape, strength, and general make-up demand conditions of support which can best be obtained by being water-borne, and cannot otherwise without more or less injury to the structure. So it happens when it becomes necessary to dry-dock or haul a ship great judgment, care, and labor are demanded to know when and how to tighten or loosen the supports and to perform the operation without seriously injuring the vessel; so much so is this the case I think it may be safely assumed that few vessels are dry-docked without sustaining more or less permanent injury."

The Atlantic Works of Boston say: "Our positive ignorance of this matter throughout forbids our expressing any opinion at length. It does not seem to us a feasible plan, and we do not believe it will ever be accomplished. Were it not that Capt. Eads has already 'done wonderful things' we should not hesitate to declare this scheme *impossible* of execution."

Opinion of C. H. Mallory, Esq., a former ship-builder, ship captain, and now a large ship-owner:

"Your favor of the 20th, asking for an expression of our opinion of the practicability of transporting loaded ships over a railroad one hundred miles 'without being water-borne' is received. * * * We have given some thought to this matter, and have believed it impossible to transport a loaded ship over miles of railroad in a cradle without being water-borne without great damage to the ship.

"It is considered highly dangerous to take a loaded ship out of water on one of our sectional or balance-docks, and it is the rule, and is required by underwriters in most instances, that the cargo in whole or part shall be discharged. It appears to me that an iron ship, loaded with heavy cargo, transported on a railroad over one hundred miles, (however smooth,) without being water-borne or some equivalent, would be very apt to require an entire new fastening of rivets before launching again."

Eads' Plan—Practical Views on the Proposed Isthmus Railway.

PHILADELPHIA, *January* 28, 1881.

To the Editor:

I notice that Captain Eads has made a proposition to build a ship-railway across the Isthmus to carry ships loaded with their cargoes, and I beg herewith to say, as a practical ship-builder, that such a proposition is nothing more than a delusion upon our people. I have built over one hundred ships, some of them the largest sailing-ships in the world, and it is with the greatest care that all ship-builders are compelled to lay the keels and see that the foundations for the launching-ways have the very best possible bearing that can be devised, so that the vessel can be

launched with safety, without injury to the hull, when sliding a distance of only one and one-half times its own length.

I also notice that our Government has been asked, and it is thought that it will endorse the measure by guaranteeing some $50,000,000. Before any enormous expenditures are made it would be well to pause and consider what we are to receive for our money after the work is done, and what are the benefits arising from it. Is the scheme a practical or a theoretical one? Speaking for myself—and I claim to speak from a practical standpoint, backed by years of experience in handling ships—I am free to say I believe the enterprise a delusion, and there is not a single naval constructor or engineer in the Government employ, who lays any claim to practicability, who would be willing to endorse such a scheme or stake his official reputation upon the success of any scheme requiring the carrying of a vessel, with her cargo, one hundred miles overland, when it is a well-settled rule among them all to prefer to sail a vessel thousands of miles rather than launch her three hundred feet with only her own weight (no cargo) upon the ways. * * *

NATHANIEL MCKAY.

THE ATLANTIC WORKS,
Builders of Iron and Wooden Steamships,
EAST BOSTON, *February* 10, 1881.

Rear-Admiral DANIEL AMMEN, U. S. N.:

DEAR SIR: Replying to yours of the 31st ult., in our opinion the railroad project will never be carried out, for the simple reason that it is not practicable and cannot accomplish the results claimed.

The opinions expressed by Mr. Nath'l McKay, in his article in *The American Ship*, is just *our* opinion regarding the railway.

As to the canal, while we confess ignorance as to details, we have no doubt of the feasibility and the beneficial results of its construction.

Very truly yours,
ATLANTIC WORKS,
ALFRED E. COX, JR.

OFFICE OF DELAMATER IRON WORKS,
NEW YORK, *February* 11, 1881.

DANIEL AMMEN, ESQ., *Rear-Admiral U. S. Navy:*

DEAR SIR: Your letter of January 31st was duly received with enclosures. We feel the subject is one that requires more careful investigation than we have been able to give the subject. We have read the articles sent us, and of course much other matter relating to this subject. We have never believed that the railroad scheme could be brought to an actual issue. We believe no private capital could be had for such a purpose. As large owners of steam vessels, we should not allow a steamer loaded with cargo to be taken out. Of course we recognize that such a feat can be done, as it is only a question of expense; but the expense would in our minds be entirely prohibitory. We have lately had experience with auxiliary power to sail vessels, fitting out three whalers, all eminently successful. We are led to remark this from a remark in one of you articles relating to sail vessels in canal. We think this subject one to be elaborated on in connection with the canal scheme. We have looked upon the difficulty of building either canal or railroad as so serious as almost to preclude the carrying out of either scheme.

We decidedly favor the canal over the railroad scheme, and it seems to us that there can be but one opinion as to the benefits to the commerce of the world, and to that of our own country particularly.

Yours, very resp'y.
C. H. DELAMATER & CO.

The above expressions of opinion comprise those of all the firms in our country, except one, which construct large iron ships.

OPINIONS OF UNDERWRITERS.

J. Parker, Esq., of New York, writes as follows: "In all my experience during the last fifteen years as an underwriter's surveyor, and in my present capacity as a manager of a book of classification, I have never known a vessel to be docked with her cargo in, except for the purpose of raising her slightly in order to reach a leak a little under water. No dock-master would consent to raise a vessel laden with the cargoes that are likely to be sent hence to San Francisco, or thence through a ship-canal, through a railway over the Isthmus of Darien, or Captain Eads' proposed route; and I am very decidedly of the opinion that no vessel so laden could safely be taken across such a railway, and then sent upon an ocean voyage. Certainly she could not be, unless a new style of naval construction were first adopted.

"As to the general subject, I suppose that, in the face of the experience of the Suez Canal, and the vast saving of time and distance worked out by that, no one can doubt that a ship-canal through the Isthmus, or Nicaragua, would be a vast benefit in every way to the commerce of this country, and to the nations generally. I do not believe it would revive our commerce, or rather, our mercantile marine; that will never be revived until the burdens it has to bear, from which the marine of all other nations are exempt, are taken off, but it will of course give additional advantages to the few vessels that now fly our flag, and are confined to the coasting trade. Yours, very truly,

"J. PARKER, *Secretary.*"

OPINIONS OF ENGINEERS.

The Honorable John Conness, formerly of the United States Senate, has forwarded the following expression of opinion of an able civil engineer in whom he has great confidence: "Admiral Ammen's testimony before the select committee, as given in the slips sent me, tells the whole story, and puts Eads' absurd project in its right light. * * * The first thing that must strike any one acquainted with shipping is the utter impossibility of transporting a loaded ship of even 1,000 tons capacity, as ships are now constructed, any considerable distance on a railway with safety. I know something of ship construction, have built and operated marine railways, and I have no hesitation in saying that I do not believe one ship in ten of our present commercial marine, loaded, can be hauled up with *perfect safety*, out of water, on any of our most complete marine railways. It is considered dangerous to allow a loaded vessel to take bottom under the most favorable circumstances. In one word, before Eads' railway (if built) could be used we would have to build ships expressly for it. Now, supposing the railway built, and the ships for it, the real difficulties have just begun. What sort of a car or cradle will he place his ship in? Will it move on wheels or rollers? If on rollers, how will he attain any speed; and if on wheels, how many will his car need to carry a weight of from 3,000 to 5,000 tons? A common freight car needs eight wheels to carry ten tons. The motive power must be from stationary engines."

Wm. J. McAlpine, Esq., second to no civil engineer in this country, wrote that he regarded the Eads scheme quite as visionary as M. de Lesseps's canal at the ocean level, and that he would discuss the subject without delay. Since that time illness has confined him to his bed, and so far delayed his expressed intention. His opinion has special value,

as he has full professional knowledge of the ground, having recently spent months examining and locating the best lines for railway between the oceans.

Lieut.-Com'r Gorringe says: "However successful Captain Eads may be in moving a laden ship across such a distance over such varying grades, the ship would not float on reaching the point where the floating would be a matter of some importance. * * * The jarring in motion, no less than the development of strains not provided for in ship construction, must inevitably open every seam and cause every rivet to leak."

In asking for and presenting information, it is worth while to state that nothing has been suppressed from a divergence or difference of opinion, which might be supposed to be the case from the unanimity or concordance of the above opinions.

EAST WAREHAM, MASS., *February* 10, 1881.

HON. JOHN CONNESS :

MY DEAR SIR : You ask my opinion on Capt. Eads' project for a ship-railway across the Isthmus, as you think I ought to know something on the subject from having had charge of the construction of railways, both marine and others, and not a little experience in canal-building. The first difficulty that presents itself to my mind in the case is the utter impossibility of transporting a loaded sea going vessel of any considerable size for any distance over land with safety without such an expenditure of time and money as would make the operation perfectly useless for practicable purposes, unless Capt. Eads has discovered some method hitherto unknown and yet unpublished for overcoming well-known physical laws. It is well understood by all ship-builders, ship-owners, and ship-masters that a loaded vessel cannot be hauled out of water with perfect safety on our best-constructed marine railways, even where the speed is so slow as to be hardly discernable ; not one vessel in ten of our merchant marine will bear the strain and jar to which they are subjected ; *hence it is never done, except in cases of the greatest emergency, and it is always an expensive operation.* Many instances can be given where unloaded vessels have been seriously injured from being hauled out on a marine railway, and innumerable are the instances where the caulking has been started and seams opened from the inequality of the strain on the different parts of the vessel. I once had a small vessel hauled out on a railway at New Bedford ; on being launched the caulking started from one of the seams, making it necessary to beach the vessel to keep her from filling with water ; and a similar case happened to me in Chesapeake Bay. It is considered dangerous for a loaded vessel to take ground, even under the most favorable circumstances. A nearly new and well-built vessel belonging to this town was seriously injured last year from grounding while coal-laden at a Boston wharf, though the wharf had been prepared for the reception of such vessels, and all danger from grounding supposed to be provided against. It is inferred by some, from the fact that loaded small boats are carried with safety on railways over inclined planes, that therefore vessels of any size can be transported on a railway, there being merely a difference of cost in the case. In 1851 I had charge of the reconstructirn of four of the inclined planes on the Morris Canal, in New Jersey, and know something of their construction and operation. The canal was used as far as was possible, and the inclined planes put in only when great differences of levels were to be overcome in a short distance. This is a vast difference between building a railway for carrying a flat-bottomed canal-boat of 100 tons burden

and four feet draught of water and one for a sea-going ship of 2,000 or 3,000 tons burden, with a draught of from 18 feet to 24 feet of water. Certainly no comparison favorable to a ship-railway can be made between them ; it might, possibly, suggest the use of inclined planes instead of locks where water was scarce, a great saving of distance made, and vessels to be built expressly for the purpose.

The grading and superstructure for a railway of sufficient strength to sustain the weight of a 3,000-ton ship must cost more to begin with than a canal of equal capacity, and the cost of keeping it in repair would be far greater than that of keeping the canal in repair. It must be perfect in its construction, beyond the possibility of getting out of order from any cause, even a change of temperature. The car or cradle in which the vessel is carried must be so devised as to give the vessel as perfect bearing as in the water ; all jars must be provided against ; the weight must be so distributed among the car-wheels that they cannot break, as an accident in course of transit from a broken wheel or derailment would be ruinous to the enterprise.

Now, when all this is satisfactorily done, the question of the power required to move this great weight with any considerable speed, and how it shall be applied, presents itself, and we are at once confronted with the fact that ships often stick on the ways in launching, and are moved down grade with difficulty, noticeably in the case of the *Great Eastern*, where every emergency was supposed to be provided for by the best engineering talent. Though there has been no positive limit yet put to the weight that can be moved, it must be done at a very slow rate when more than a comparatively few tons are in one body.

These considerations are conclusive to my mind against the economic practicability of Capt. Eads' project, and why the nation should not assist him in its demonstration any more than it should any person who should propose to carry a ship across the Isthmus in a balloon.

Very truly, yours,
A. SAVARY, *Civil Eng'r.*

A.

HYDROGRAPHIC OFFICE, *February* 17, 1881.

Capt. J. C. P. DE KRAFFT, *U. S. N.*,
Hydrographer :

SIR : In obedience to your order of the 15th inst., I have the honor to state that I have carefully measured the following distances according to the routes which would be followed by a careful navigator, and that my measurements have been carefully examined by Lt.-Commander C. H. Davis and have been found correct :

New York (Battery) to Greytown (steamer)...........	2,028	naut.	miles.
" " " " (sailing vessel)......	2,028	"	"
" " " Coatzacoalcos " "	2,042	"	"
" " " " (steamer)............	1,982	"	"
New Orleans to Coatzacoalcos..............................	802	"	"
" " Greytown....................................	1,308	"	"
Brito Point to Ventosa..	604	"	"
Ventosa to San Francisco.....................................	2,100	"	"

Very respectfully,
Your obedient servant,
F. M. GREEN, *Lt-Comd'r.*

A[1].

HYDROGRAPHIC OFFICE,
NAVY DEPARTMENT, *May* 23, 1881.

SIR : In obedience to your order, Lieut. A. G. Berry, U. S. N., and

myself, have made on the charts published by this office careful measure ments of the distances between the following places, viz.:

	Nautical Miles.
Panama to San Francisco	3,245
" " Ventosa	1,160
New Orleans (foot of Canal street) to Aspinwall	1,384
New York (Battery) to Sabine Pass	1,900
Cape Florida to Cape Race	1,835
Brito to San Francisco	2,670
Head of Gulf of Darien to Ventosa Bay (measured along the axis of the Isthmus)	1,230

Very respectfully,

SAM'L BELDEN, *Lieut. U. S. Navy.*

Capt. J. C. P. DE KRAFFT, *U. S. N.*,
Hydrographer.

B.

WASHINGTON, D. C., *March* 12, 1881.

Capt. S. L. PHELPS:

Having been interested in the working of the caisson at the outlet lock of the C. and O. Canal, above Georgetown, D. C., for some time, my attention being first called to it by the necessity for a favorable solution of the problem as to introducing canal boats from the canal to the river. In 1876 a "Constructing Engineer" and myself went over the work, but arrived at the conclusion that the best means had not yet been attained, which subsequent events seemed to prove. The gearing, not being adapted to the heavy strain, gave way, causing the death of at least one, and I think more, of the employés.

My attention has been again drawn to the matter, since the proposed construction of a ship-railway on the Isthmus.

I have taken some pains to have the verdict of our steam-tug and canal boatmen, who are most interested, and below have given their testimony, generally in their own words, prefacing the statements, however, with the size and weight of the caisson, which is 112 by 15 feet, and weighs, when filled with water, 400 tons:

Captain A. C. Wilkinson, of the steamer *W. Moore*, says that a perfectly new boat may stand the strain, but an old boat never leaves the tank without sustaining such damage as to cause her to leak badly; that he's afraid to go in the tank, now that they take the water out and let the boat down on the bottom of the tank, straining her and opening all her butts. He has seen the rails chewed up like so much paper by the truck wheels, and men replacing the worn rails almost every night, though the rails were much heavier than common; that the track settled badly, except in the part where it was solid stone masonry under the whole track; that is, from side to side. He thinks they have put stone under every portion of it during the past winter; is sure that is the only way to prevent the heavy weight from sinking right down, (and yet this is only 400 tons distributed over 112 by 16 feet.)

The steamer *Ludlow Patten* always leaks terribly after going in the caisson. She sprung two of her deck beams last season, and would not go into the river that way, if there was water enough in Rock Creek.

Canal boat *Nathan Williams*, Capt. Zimmerman, always leaks after going into the tank with a load; does not suffer when going up light, as then the tank is filled with water. Canal boat *Blue Bell*, Capt. Russell, and several others, make the same report.

Canal boat *Johnson*, Capt. Milliard Engle, though comparatively a new boat, (this being her first season,) yet shows the strain; her deck plank butts gaping wide open every time she enters the tank with a load.

Canal boat *F. W. Winthrop* suffers terribly every time she goes into the

tank with a load. The captain wishes the old tank was out of the way. He is afraid every time he enters it, except when he is empty.

Captain James Christy, tug-boat *Major*, says he has towed many of the canal boats from the caisson to Georgetown, and never heard one of the captains speak in its praise; on the contrary, all condemn it, and many say they are afraid of it when they go in loaded. He heard that last year a boat was so badly injured that she sunk immediatedy after leaving the caisson.

Capt. T. Milstead, tug-boat *A. P. Gorman*, says he has towed a large number of canal boats from the incline to Georgetown and back; does not remember to have heard many captains praise it, but has heard almost all say they were afraid of it. He towed the canal boat *Kennah* in December, 1880. She was injured so badly that he saw she was settling directly she came out of the caisson, and he ran her ashore as soon as he could, when she sunk.

Yours truly,

J. H. HALL.

C.

UNITED STATES ENGINEER OFFICE,
26 *Washington Avenue*,
DETROIT, MICH., *July* 14, 1879.

MY DEAR DAVIS:

I have received your letter of the 8th instant.

I expect to be able to pass a single vessel through the new lock at St. Mary's Falls Canal, when everything is in good working order, in 11 minutes, as follows, viz:

Entering lock chamber	1½	minutes.
Closing gates	1	"
Filling lock	6	"
Opening gates	1	"
Leaving lock chamber	1½	"
Total	11	minutes.

The chamber is 515 feet long and 80 feet wide, except at the gates, where it is reduced to 60 feet, in order to diminish the size and weight of the gates. There is a single lift of 18 feet.

The gates of the old locks are operated by very primitive methods and by hand. The chambers are 350 feet long and 70 feet wide. There are two lifts of 9 feet each. Thirty-seven vessels have been passed through the locks in 22 lockages in 22 hours.

The chambers of the new locks of the Louisville and Portland Canal are 372 feet long and 80 feet wide. There are two lifts of 14 and 12 feet. The gates are very heavy. One leaf of the middle gates weighs over 90 tons. The machinery for operating the gates is worked by hand. Yet we have made 29 lockages in 21¼ hours. I am now applying engines to each capstan, and will operate these engines by compressed air. I also have commenced rebuilding the gates in order to get them lighter.

* * * * * *

There is no other ship-canal at just such a place as this one, and no other ship-canal can be compared to it on account of the immense quantities of silt.

The new lock at the St. Mary's Falls Canal is the largest canal lock in the world. There is a dead lock in Liverpool, between the north basin and the Canada Dock, which is 100 feet wide and 500 feet long.

To pass the *Ville de Paris* through a lock of 12-feet lift with modern improvements would require about 8 minutes.

* * * * * *

Very truly yours,

G. WEITZEL.

Major GEO. W. DAVIS, *Washington, D. C.*

D.

UNITED STATES ENGINEER OFFICE,
26 *Washington Avenue*,
DETROIT, MICH., *July* 31, 1879.

MY DEAR DAVIS:

* * * * * *

As far as my time has permitted, (I am not allowed to read at night,) I have looked over Mr. Menocal's designs and estimates.

His design appears feasible. His estimates are close, but he has added a large percentage for contingencies.

He ought to increase the capacity for filling and emptying the locks, so as not to take more than from 6 to 8 minutes. Each lock should be provided with guard-gates on each end, so that they can be pumped out for repair.

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Very truly yours,

G. WEITZEL.

Major G. W. DAVIS, *U. S. A.*, *Washington*, *D. C.*

E.

OFFICE OF W. R. HUTTON, *Civil Engineer*,
46 *Lexington Street*,
BALTIMORE, 24th *March*, '81.

MY DEAR ADMIRAL:

The angle of inclination of the incline for boats above Georgetown is 6° 50′, or a rise or fall of 1 in 12. The counterweights which balance it slope 1 in 10.

I have read Eads' paper in *N. A. Review*. I have not the time just now to investigate the strains in a loaded ship on his railway, as under other circumstances I would do; but his paper is open to criticism. He refers to the canal-boat incline, but no comparison can be made between that work and his project. In that the boat was carried in water, in order to maintain always the same weight in the caisson independently of the weight of the boat, so that a uniform counterweight would always balance it within the limits permitted by the friction of the wheels, &c. The friction has been so far beyond anything we could have expected, rendering unnecessary any nice balancing of weights, and the loaded boats which do not vary in weight more than ten or twelve tons (and very rarely so much) are now carried down resting on the bottom of the caisson, the light boats only being carried afloat in about 20 inches of water.

Your idea of the effect of the overhang is correct; only the pressure upon the end wheels depends upon the *stiffness* of the ship. If she were *perfectly* rigid, the weight would be evenly distributed over all the wheels, supposing *perfect* workmanship. The more flexible the ship the greater the pressure on end wheels. It would be more rational to increase the number of supports at the heaviest part and diminish where lighter.

I will be very glad to see Phelps' paper when published.

Very truly yours,

WM. R. HUTTON.

Admiral D. AMMEN, *Washington*.

The following letter was received after the printing of my comments on Captain Eads' project. S. L. P.

NEW YORK, *June 3d*, 1881.

ADMIRAL:

DEAR SIR: While returning from Mexico and on the steamer, I wrote a paper in which I thoroughly examined the Eads scheme of a ship-railway across the Isthmus of Tehuantepec.

I had then just finished an exploration of the route which Mr. Eads' engineers had selected for his ship-railway.

This paper was sent to a gentleman in Mexico with a view to have it laid before the Government.

I intend to rewrite this paper for use before the Congress of the United States, and would be glad of any information or facts touching this subject which you may have collected, and upon which I can comment in my paper.

In your recent letter you speak of having obtained the opinions of all of the leading ship-builders in the United States (except one) condemning this scheme. I would be obliged to you for a copy of one or more of these opinions.

In my paper, I have described from *personal* surveys the route which his engineer has selected, and have spoken of the enormous cost and difficulty of carrying his roadway across the deep swamps of one-half at least of the first 60 miles, from near Minititlan; of the rough country of the mountain section over which his line must pass, crossing numerous streams, (tributaries to the Cortez river,) and the repeated changes of grades and lines rendered necessary thereby; of the south descent of the Sierra Madre slope, (500 feet in 4 miles,) and of the equally costly and difficult cutting through of the coast range; of the difficulty of vessels descending into the constant turbulent Pacific (?) sea; of the mechanical impossibility of at all times equally distributing the weight of the ships, cargo, and cradle on 1,200 wheels over six ordinary railroad tracks, so that sometimes a hundred or less number of wheels must carry the whole load, and hence that the substructure must be immensely stronger than any railroad ever built; of the cost of the United States dry-dock at Brooklyn as an example, its foundation to support only 3,000 tons on firmer ground, cost more than at the rate of $500,000 a mile; of the inequalities of the surface of the rails of the best built railroads in the world, causing constant concussions with the maximum weight of forty tons, and would be multiplied by weights of five thousand to ten thousand tons, sufficient to destroy almost any track that could be built, (the concussive effect being as 125 or 250 to 1,) hence a speed of not exceeding one mile an hour would be necessary, or 150 hours for crossing the Isthmus; of the difficulty, impossibility, of supporting a ship out of her element by shores which would only sustain the places where they were inserted, while at sea the ship has identically the same support (displacement) at every instant of time, no matter how rough the sea may be; of the tropical hurricanes which prevail on the Isthmus, when the whole broad-side of the ship, from her keel to her bulwarks, is exposed to the gale; that is, twice as much surface, besides top-hamper, as when afloat, and that the centre of gyration (turning) when afloat is, say, 4 to 8 feet below the surface of the water, but on the ship-railway is 5 to 10 feet *below the keel*, so that these hurricanes have twice the leverage to capsize the vessel, and, with double the area exposed, the hurricane has four times the power to overturn her; of the necessity of stopping at each change of grade or line to move the ship and cradle by turn-table, &c., producing delays greatly more than locks would cause.

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I write from recollection, and only give you these points to show the line of my argument.

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In great haste,

I am, very truly and resp'y yours,

WM. J. MCALPINE.

Admiral DAN'L AMMEN,

Washington.